

FGDC Proposal, Version 1.0

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FEDERAL STANDARDS FOR DELINEATION OF HYDROLOGIC UNIT BOUNDARIES

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1. Introduction

1.1 Purpose

This document establishes interagency standards and guidelines for creating and delineating hydrologic unit boundaries, modifying existing hydrologic units, and establishing a national Watershed Boundary Dataset (WBD). This standard does not provide specifics of the development of the WBD. But, it does provide guidance into developing data that will be incorporated into the WBD. The standards are to be used by agencies and tribes for developing a single, seamless, nationally consistent, and accurate geospatial database of hydrologic units based on scientific hydrologic and mapping principles. The standards are designed for use in all states and island territories and are designed to meet local, regional, or national needs.

This standard sets forth terminology, definitions, and guidelines to ensure the uniform development of hydrologic unit boundaries by the agencies, tribes and organizations that develop, manage, archive, exchange, and analyze data by hydrologic features. The standard will enable a variety of users from different agencies and programs to contribute to an overall coordinated watershed management approach, to efficiently share information and resources, and to assure the geospatial database is usable with other related Geographic Information System (GIS) databases.

The criteria and methods for hydrologic unit selection and boundary delineation will permit standardized hydrologic units to be used by a diverse group of users serving multi-agency programs. Some examples of these programs include watershed management, water quality initiatives, watershed modeling, resource inventory and assessment, and establishing total maximum daily loads. The utility of hydrologic units of various size and complexity based primarily on natural surface water flow and topographic landforms cannot be underestimated for the potential invaluable analytical and statistical purposes and applications at hydrological and ecosystem scales.

When the WBD is completed for the nation, the GIS layers and associated maps should remain reasonably stable. Updates to the WBD are addressed in Section 5.6. For the latest information on hydrologic unit delineation to the 5th and 6th level go to http://www.ftw.nrcs.usda.gov/huc_data.html

1.2 Background

A standardized hydrologic unit system, referred to as the Hydrologic Unit Code system, was developed in the mid-1970's by the U.S. Geological Survey (USGS) under the sponsorship of the Water Resources Council. This system divided the country into 21 Regions, 222 Sub-regions, 352 Accounting Units (hereafter referred to as Basins), and 2,149 Cataloging Units (hereafter referred to as Sub-basins) based on surface features. A hierarchical hydrologic unit code containing 2 digits for each of the four levels was assigned to identify the hydrologic units; these four levels are the basis for the 8-digit hydrologic unit code. The underlying concept is a topographically defined set of drainage areas organized in a nested hierarchy by size.

The standardized 8-digit USGS hydrologic units (Levels 1,2,3 and 4) are broadly used; however, the geographical area of the units are too large to adequately serve many water-resource investigations, resource analysis and management needs. For example, the focus of many water resource issues is based upon pollutant loading and land-surface processes, and the cumulative effects of pollution

over space and time. Management of these issues requires working with hydrologic units in smaller sizes than those defined by the 8-digit hydrologic units. Examples of programs requiring smaller hydrologic units include State River Basin Management Plans, the United States Department of Agriculture (USDA), Natural Resources Conservation Service (NRCS) conservation and watershed programs, USDA Forest Service land management planning and watershed management programs, and various programs in the Environmental Protection Agency, Office of Water.

The NRCS is responsible for working with landowners to protect, improve and sustain natural resources on private lands. The NRCS completed mapping watersheds (Level 5 hydrologic units) in the early 1980's on small-scale state base maps for use in natural resource planning. In the mid-1990's, the NRCS along with State agency conservation partners began a national initiative to delineate and digitize watersheds and subwatersheds on base maps meeting national map accuracy standards. To promote a standardized criterion for hydrologic unit determination and delineation, the NRCS developed National Instruction 170-304 in 1992 that served as the agency's policy for delineating and digitizing watersheds and subwatersheds. The NRCS updated the policy guidelines in 1995 incorporating changes from internal and external reviews. The NRCS has made considerable contributions to the development of a national standardized geospatial database of watershed and subwatershed boundaries.

The U.S. Forest Service and the Bureau of Land Management (BLM) are the primary land management agencies of federal lands in the U.S. Both agencies are delineating and digitizing watersheds and subwatersheds on public lands. The delineation is primarily done on public lands in the western states, however, often all land ownerships are delineated within a sub-basin. Earlier delineations of hydrologic units of federally administered public lands served administrative purposes but were often developed without full coordination between federal and state agencies.

The USGS and member agencies of the Federal Geographic Data Committee (FGDC), Subcommittee on Spatial Water Data has been coordinating and conducting a series of regional workshops to promote the development of a nationally consistent hydrologic unit coverage. The USGS, USFS, BLM, and NOAA are assisting NRCS in the review and verification of hydrologic units. The USGS, EPA and the National Weather Service are researching techniques to employ digital elevation data for producing hydrologic unit delineations which act as concept lines to adjust to 1:24,000 contour lines where needed.

The NRCS, Forest Service and BLM have worked with the USGS, other federal and state agencies, tribes, and with the FGDC, Subcommittee on Spatial Water Data to establish these "Federal Standards for Delineation of Hydrologic Unit Boundaries". This standard builds upon the original NRCS National Instruction 170-304, and establishes the principles and standards that federal agencies should follow in making subdivisions of the 8-digit USGS sub-basin hydrologic units. These standards are not agency specific, and have been agreed upon by member agencies of the Subcommittee on Spatial Water Data.

2. Coordination

2.1 FGDC Subcommittee on Spatial Water Data

The Subcommittee on Spatial Water Data was chartered and sponsored by the Advisory Committee on Water Information (ACWI), and the FGDC. The Spatial Water Data Subcommittee coordinates spatial water data and information activities among all levels of government and the private sector. Spatial water data includes information about streams, hydrologic units, lakes, ground water, coastal areas, precipitation and other hydrologic information related to water resources.

Federal agencies having major involvement in the development and application of hydrologic units and water resources management responsibilities are encouraged to participate as members of the Subcommittee on Spatial Water Data.

The Subcommittee on Spatial Water Data assists the ACWI and FGDC by facilitating the exchange and transfer of water data, establishing and implementing standards for quality, content and transfer of water data, and coordinating the requirements and the collection of spatial data to minimize duplication of efforts.

2.2 State-Regional Coordination

The delineation of hydrologic units into "watersheds" and "subwatersheds" is an opportunity to develop a consistent and common nationwide geospatial database for interagency sharing, and for improving federal, state, and local uses of hydrologic units. States are encouraged to form an Interagency Hydrologic Unit Group composed of hydrologic GIS data users. A permanent or rotating chairperson should be selected. Adjoining states or regional parties should be invited to participate. The group would promote the development, use, and maintenance of the hydrologic unit geospatial database, and provide a forum for coordination and consensus among federal, state, and local agencies, and watershed entities.

All states within a sub-basin should coordinate their delineation work to prevent having the need to make difficult changes and modifications later to make the geospatial database match across state borders. This coordination should cover the locations of outlet points, the size of the watersheds and subwatersheds, and the coding sequence within each level of the hydrologic unit hierarchy. The mapping and edge matching of hydrologic boundaries crossing county and state boundaries must be coordinated to assure that a nationally consistent database is created.

State coordination groups can help to prioritize the delineation of hydrologic units and define their uses and applications. The participants should agree to establish procedures for quality control, coordination and management of the hydrologic unit delineation project. Opportunities to obtain financial support, in-kind services and cost sharing should be explored.

Differences in hydrologic unit delineations and attributes at 1:24,000 scale must be resolved. In the event a drainage unit lies in several administrative designations, each entity has the responsibility to delineate the hydrologic boundaries at the scale appropriate to all interests and to obtain mutual technical approval.

Some states have state statutes directing a specific state agency with the responsibility to delineate, manage, maintain, and coordinate the hydrologic units within the state. Federal agencies involved in the development of the national WBD need to coordinate with these responsible state agencies.

3. Definitions

3.1 Hydrologic Definitions

Basin. The third level (6-digit) of the hydrologic unit hierarchy. Basins are nested within or are sometimes equivalent to sub-regions. Basins were formerly named "accounting units."

Classic Watershed. A land and water area that has all the surface drainage within its boundary converging to a single point.

Composite Hydrologic Unit. A land and water area that receives surface flow from an upstream watershed (s) and drains to one outlet.

Contiguous Boundaries. Hydrologic unit boundaries shared in whole or in part by different hydrologic units.

Estuary. The wide lower course of a water passage where its current is met by the tides.

Frontal Hydrologic Unit. A land and water area where surface flow originates entirely within the hydrologic unit and drains to multiple points along a large waterbody such as the ocean or large lake.

Hydrography. The scientific description, study and analysis of the physical conditions, boundaries, measurement of flow, investigation and control of flow, and related characteristics of surface water such as rivers, lakes and oceans.

Hydrologic Unit (HU). A hydrologic unit is a drainage area delineated to nest in a multi-level, hierarchical drainage system. Its boundaries are defined by hydrographic and topographic criteria that delineate an area of land upstream from a specific point on a river, stream or similar surface waters. A hydrologic unit can accept surface water directly from upstream drainage areas, and indirectly from associated surface areas such as remnant, non-contributing, and diversions to form a drainage area with single or multiple outlet points. Hydrologic units are only synonymous with classic watersheds when their boundaries include all the source area contributing surface water to a single defined outlet point.

Hydrologic Unit Code (HUC). The numerical identifier of a specific hydrologic unit consisting of a 2-digit sequence for each specific level within the delineation hierarchy.

Hydrologic Unit Name. A name assigned to hydrologic units for better identifying and understanding the geographic location of the hydrologic unit. Hydrologic units are usually named after significant or prominent hydrographic features in an area, however hydrologic units may be named after non-hydrographic features if better understood by the users and public.

Hydrology. The science dealing with the properties, distribution, and circulation of water on the surface of the land, in the soil and underlying rocks, and in the atmosphere.

Karst. A type of topography that is formed over limestone, dolomite, or gypsum by dissolving or solution, and that is characterized by closed depressions or sinkholes, caves, and underground drainage. Underground drainage through interconnected networks of karst conduits can also be present in areas underlain by soluble rocks that do not exhibit karst topography.

Lake Hydrologic Unit. A large lake, reservoir, or playa which can have flow from adjacent frontal, composite, and classic hydrologic units. Generally these units would not contain any further delineation at the next lower hydrologic unit level.

Non-contributing area. An area within a hydrologic unit that normally does not contribute directly to the surface runoff to the river or stream at the outlet of the hydrologic unit.

Open-Water Flow Channel. The deeper portion of an estuary or sound that is large enough to be defined as a separate HU. It conveys flow, possibly in both directions, and is bound laterally by coastal land HU's or shoals.

Open-Water Hydrologic Unit. A water based HU existing within a large open body of water. Land is not a major portion of the HU, but may be included as in the case of islands.

Open-Water Mixing Basin. A relatively broad portion of an estuary or sound confined by shoals and/or coastal land HU's that has a long retention time for in-flows.

Region. Regions are the largest drainage basins, containing either the drainage area of a major river or the combined drainage areas of several rivers. Regions (2-digit) are the first level in the hydrologic unit hierarchy.

Remnant Areas. These areas are typically formed as residual areas after delineation of classic watersheds. The most common example of a remnant area is the small triangular wedge between the boundaries of adjacent watersheds flowing into the same side of another stream.

Shoal. An underwater permanent geomorphic feature, usually a sand bank or sand bar, that makes the water become shallow and impedes or directs flow.

Sound. A long broad inlet of the ocean connecting two larger bodies of water or passing between an island and the mainland.

Sub-basin. Subdivisions of basins. The sub-basin is the fourth level (8-digit) of the hydrologic unit hierarchy. Sub-basins were formerly named "cataloging unit". The average size is about 450,000 acres.

Sub-region. Subdivisions of regions. The sub-region is the second level (4-digit) of the hydrologic unit hierarchy.

Subwatershed. Subdivisions within watersheds. Subwatershed is the sixth level (12-digit) in the hydrologic unit hierarchy. Subwatersheds generally range in size from 10,000 to 40,000 acres.

Toe of the Shore Face. The depth to which seasonal storms and prevailing winds and resultant waves and currents move shallow sediments to and from the shore. Water depth decreases rapidly, and then slowly between this geomorphic feature and the shore.

Watershed. Subdivisions within a sub-basin. The 5th level (10-digit) in the hydrologic unit hierarchy. Watersheds range in size from 40,000 to 250,000 acres.

3.2 Geospatial Definitions

Attribute. A quality or characteristic describing a map feature. The attributes of a hydrologic unit include its code, size, or name. An attribute is one of two main types of data in a GIS; the other is geospatial data.

Contour. An imaginary line on the ground representing the land surface. All points on a contour line are of equal elevation.

Coordinates. Linear and (or) angular quantities designating the position of a point in relation to a given reference frame. In a 2-dimensional system, x and y coordinates are used to designate locations.

Compilation. Preparation of a new or revised map from existing maps, field surveys, and other sources.

Datum. A basis and reference for a geodetic survey. Refers to a direction, level, or position from which angles, heights, depths, speeds and distances are normally measured. Datum as applied to a horizontal geodetic survey is a reference based on the shape of the earth. The vertical datum is usually mean sea level or mean lower low water, and usually referred to as NGVD or National Geodetic Vertical Datum.

Delineation. To outline the boundaries of a hydrologic unit with a line.

Digital Elevation Model (DEM). Geo-referenced digital files consisting of terrain elevations for exposed or submerged ground positions at regularly spaced horizontal intervals, generally 10 to 30 meters. Stored in a database and typically used to represent terrain relief.

Digital Raster Graphic (DRG). A scanned geo-referenced image of a USGS standard series topographic map or NOAA Nautical Chart. The map image is georeferenced to the surface of the earth. The horizontal positional accuracy matches the accuracy of the original map.

Elevation Derivatives for National Applications (EDNA). The development of a hydrologically correct version of the National Elevation Dataset (NED) and systematic derivation of standard hydrologic derivatives (previously known as NED-H).

Edge matching. A procedure used to ensure hydrologic unit boundaries crossing adjoining maps match and connect to create a continuous or seamless line between maps.

Coordinate System. Any system where points on the earth's surface are located with reference to a

pair of intersecting lines or grid. The three major coordinate systems used in the United States are the Geographic Coordinate system, State Plane Coordinate system, and Universal Transverse Mercator Grid system. Each of these coordinate systems has unique characteristics and usability.

Geographic Information System (GIS). A computer system designed to collect, manage, manipulate, analyze, and display spatially referenced data. A GIS includes both attribute and geospatial data. The primary components of a GIS are software, hardware, data and people.

Geospatial. One of two main types of data in a GIS (the other being attribute data). Geospatial data represents the shape, location or appearance of geographic objects. Hydrologic units are digitized and stored as vector geospatial data.

Hypsography. A branch of geography that deals with the mapping of the topography of earth above sea level.

Metadata. Details about data. The description and documentation of the content, quality, condition, and other characteristics of geospatial data.

National Map Accuracy Standards (NMAS).

(<http://mac.usgs.gov/mac/isb/pubs/factsheets/fs17199.html>) Specifications governing the accuracy of topographic, base, orthophoto and other maps produced by federal agencies. The watershed (10-digit) and subwatershed (12-digit) hydrologic unit boundaries are to be delineated and georeferenced to the USGS 1:24,000 scale topographic maps that meet the NMAS standard.

National Hydrography Dataset (NHD). NHD is a combination of the US-EPA River Reach files and USGS Digital Line Graph (DLG) hydrography geodata files. The NHD is available nationally at 1:100,000 scale at <http://nhd.usgs.gov/>.

Neatline. The lines on a map serving as the outside border or limits of the map sheet.

National Elevation Dataset (NED). The USGS National Elevation Dataset (NED) has been developed by merging the highest-resolution, best-quality elevation data available across the United States into a seamless raster format.

NOAA Nautical Chart. A lithographic printed chart which represents the horizontal and vertical positions of submerged land, shoals, navigational hazards, navigational channels, navigational aids, shoreline and adjacent cultural features. Scales vary with location. Virtually complete coverage of the US coast, including Great Lakes, is available at a scale of 1:80,000 except for Alaska.

Polygon. A closed loop of x, y coordinate pairs defining the boundary of an area. A series of straight lines, arcs, or combinations of both often define the polygon.

Raster Digitizing. Point, line, and polygon features from a map are stored as a matrix of cells or pixels of a uniform grid. Map features are defined by numeric values assigned to the cells.

Topographic quadrangle. A USGS lithographic printed map that represents the horizontal and vertical positions of cultural, political and land features. Map symbols are used to depict such symbols as mountains, drainage, roads, and county boundaries, usually at scales of 1:100,000 or 1:24,000.

Topology. The spatial relationships between connecting and adjacent features. Topology defines the location of geographical phenomena relative to each other, but is independent of distance or direction. Topology depicts connectivity of one entity to another. Topology is required for proper associations to be made among such features as arcs, nodes, points, and polygons and their attributes.

Vector data. A coordinate-based data structure used to represent geographic features in line, point and polygon.

Vector digitizing. The process of using a digitizer to encode the locations of geographic features by converting their map positions to a series of x-y coordinates. Geographic objects are digitized as a line, point, or polygon. A point is represented by a single coordinate, a line by a string of coordinates, and an area or polygon by one or more lines making up the polygon.

Verification. Hydrologic units have been reviewed and meet the criteria as stated in the "Federal Standards for Delineation of Hydrologic Units" as agreed to by member agencies of the Subcommittee on Spatial Water Data.

Watershed Boundary Dataset. National geospatial database containing the hydrologic unit boundaries for the 1st through 6th level units. Also includes the required attribute and metadata information.

4. Criteria to Delineate Hydrologic Unit

4.1 General Criteria

This section describes criteria for determining and delineating hydrologic units at the watershed and subwatershed levels. The selection and delineation of watersheds and subwatersheds requires good hydrologic judgement, and must be determined solely upon science-based hydrologic principles to assure a homogeneous national seamless digital data layer.

With the diversity of hydrologic conditions nationwide, complexity of surface hydrology, and the number of factors involved in the delineation process preclude an all-inclusive guideline. Variations will generally be limited to unusual hydrologic or landform features, dissimilar hydrologic or morphologic drainage area characteristics, and previously delineated units with a long history of use. The intent of defining hydrologic units is to establish a base-line drainage boundary framework which has complete accountability of all land and surface areas. The hydrologic units must be delineated and georeferenced to the USGS 1:24,000 scale topographic base map which meets National Map Accuracy Standards (NMAS).

The delineation shall be as simple as is practical, and will avoid making hydrologic units favor a particular agency, program, administrative area or special project. Drainage boundaries generated for special purposes not meeting the following standards will not be verified into the national Watershed Boundary Database.

4.2 Hydrologic Boundaries

Appendix A, Exhibit 1 illustrates six nested levels of the Hydrologic Unit hierarchy. Sub-basin boundaries (4th level/8-digit) provide the basis for the delineation of watersheds (5th level/10-digit) and watershed boundaries provide the basis for delineation of subwatershed (6th level/12-digit) hydrologic units. Sub-basin boundaries may be changed or adjusted when the existing mapping does not conform to hydrologic and topographic criteria. Notify the USGS before making changes or revisions to sub-basin boundaries (refer to Section 5.6 for Updating and Revising Hydrologic Units).

Watersheds and subwatersheds, like other hydrologic units, are defined along natural hydrologic breaks based on land surface, surface water flow, and hydrographic features. Delineated boundaries define the land area extent of the watersheds and subwatersheds. A hydrologic unit has a single flow outlet except in frontal, lake, or playa (closed basin) hydrologic units. Hydrologic units that have their outlet at a delta should be treated similar to frontal hydrologic units, therefore having more than one outlet. Give priority to delineating watersheds and subwatersheds that will be "classic" by not having subdivided upstream areas and by having only one outlet. Because watersheds and subwatersheds are subdivisions of a higher level hydrologic unit, they must share common boundaries with the existing hydrologic units defined in the next higher level of the hydrologic unit hierarchy.

Some earlier versions of watershed and subwatershed boundaries used administrative boundaries to define hydrologic units. Hydrologic unit boundaries must be determined solely upon hydrologic features. Do not use such administrative or political boundaries as county, state, national forest or other similar boundaries as criteria for defining a hydrologic unit boundary unless the administrative boundaries are coincident with topographic features that appropriately define the hydrologic unit. Although it may be impractical to make wholesale revisions to existing datasets that used administrative boundaries for delineating hydrologic units, these datasets would not be verified as meeting these standards until the hydrologic units are revised based on land surface, surface water flow and hydrologic features.

Stop hydrologic unit delineations at the international boundary of the United States or at the Toe of the Shoreface for ocean-facing HU's. Revisions to mapped hydrologic units will be accommodated if delineation agreements are reached with countries neighboring the United States.

Hydrologically based boundary delineations include land areas on both sides of a stream flowing toward a single downstream point, except in the case of open-water HU's. Boundaries should not follow or run parallel to rivers or streams except where some physical feature prevents water flowing directly to the water surface such as levees, berms, incised channels, and similar structures. Do not delineate boundaries by delineating down the middle of a stream. Boundaries will cross the river or stream perpendicular to flow at the hydrologic unit outlet. An exception would be to cross a wide river at a slight angle to eliminate unwanted remnant areas. Where a river boundary outlet crosses at a wide tributary outlet, the delineated river boundary should connect to the upstream bank of the tributary. Information from stream gages, locations of major highway crossings, and NHD reach end points may be considered to help delineate points for dividing hydrologic units.

In the case of a long, narrow hydrologic unit that is typical of a parallel drainage system, the

hydrologic unit boundary shall cross the stream or river at a significant confluence to divide the hydrologic unit into suitable sized watersheds or subwatersheds. Tributary catchment area may be a useful tool for determining the relative significance of tributaries within an area being subdivided. The hydrologic unit boundary may use smaller tributaries as the delineation point to divide the hydrologic unit into suitable sized watersheds or subwatersheds. Delineating the boundary just above a confluence allows for proper nesting of smaller units within the hydrologic unit for future site-specific planning, assessment, monitoring, or inventory activities.

In addition to the primary criteria, there are general criteria for the number of hydrologic units subdivided from a parent unit, the size of hydrologic units, and the treatment of non-contributing and remnant areas.

4.3 Number of Subdivided Hydrologic Units

As a general rule and guide, subdivide each hydrologic unit into 5 to 15 units. For example, 5 to 15 watersheds (10-digit) will be nested in each 8-digit sub-basin. This approach will accommodate geomorphic or other relevant basin characteristics, and is recommended for developing a fairly uniform size distribution of same-level HUCs within a broader physiographic area. Using this approach will also result in a smooth transition between sizes of same-level hydrologic units as topography changes between physiographic areas, and help to maintain consistency of delineations crossing state borders.

There are exceptions to using the 5-15 rule just as there are many existing sub-regions comprised of less than 5 basins, and many basins comprised of less than 5 sub-basins. It is recognized that occasionally the number of watersheds nested within sub-basins or the number of subwatersheds nested within some watersheds may also be reduced or expanded to accommodate special areas.

4.4 Size of Hydrologic Units

The hydrologic units of any given level should be about the same size within a physiographic area. There should not be any hydrologic units that are several orders of magnitude different in size than the rest of the hydrologic units for a given level.

Nationally, the typical size for a watershed is 40,000 to 250,000 acres. Use this acreage range as a guide in subdividing 8-digit sub-basins that are atypically larger or smaller than the national norm. Each watershed must be completely contained within one 8-digit sub-basin.

The typical size for a subwatershed is 10,000 to 40,000 acres. Each subwatershed must be completely contained within one watershed. In unique areas, the subwatersheds may be smaller than 10,000 acres, but never less than 3,000 acres.

Exceptions to making these hydrologic units smaller than the above guidelines may be the result of very small remnant drainage units required to preserve and enhance hydrologic unit segmentation, unusual or extreme topography, coastal areas, etc. It is important to remember that these standards and guidelines are primarily for delineating hydrologic units to the 6th level in the hierarchy system.

4.5 Classic Watershed

The classic watershed is a pure hydrologically defined surface water drainage area (*Exhibit 2*). All of the surface drainage is contained within the classic watershed boundary and converges at a single outlet point.

Delineate by starting from the designated outlet (a point on a single stream channel that drains this area), and proceed to the highest elevation of land dividing the direction of water flow. This boundary connects back to the designated outlet where it will cross perpendicular to the stream channel. Boundaries also follow the middle of the highest ground elevation or halfway between contour lines of equal elevation.

Subdivide a classic watershed by delineating the primary tributary streams and closed basins within the unit. Correctly selecting the outlet point is critical to delineating all hydrologic units accurately. The classic watersheds are those defining major tributaries to the larger "parent" hydrologic units. When choosing between tributaries for hydrologic unit definition, higher order streams are typically chosen over smaller tributaries. The downstream end of the hydrologic unit will be just upstream of the confluence with the main stem of the higher-level hydrologic unit or the main stem of a same-level hydrologic unit if possible.

A situation where this definition may not be realistic is where the drainage area is exceptionally elongated and without tributaries, and size criteria dictate dividing the unit. The boundaries should be as simple as possible, allowing full accountability of area and water yield. Hydrologic units may be divided at a lake outlet if the upstream drainage area size is appropriate for the hydrologic unit level being delineated.

Determining classic watersheds, and defining them with the recommended number of subdivisions and area sizes will cover much of the land to be delineated, however, "special situation" land areas such as remnant, non-contributing, and diverted areas will need to be delineated to different criteria covered in the following sections. These special situation areas typically need to be added in with an adjacent hydrologic unit, but occasionally, may have to exist as small atypical hydrologic units.

4.6 Remnant Areas

The delineation of hydrologic units may result in remnant areas around the main stem of larger streams, even when good hydrologic judgement and other factors described above are used. These remnant areas also have been referred to as "related contributing drainage areas" or "composite" areas. Remnant areas typically occur as wedge-shaped areas along inter-fluvial regions between adjacent watersheds, or as overbank areas along a stream between junctions with tributaries.

Remnant areas also occur in coastal outlet areas to several mainland or island watersheds that are individually smaller than defined for a given hydrologic unit level. Another example of a remnant area is when a number of streams that have outlets into the ocean are grouped into a single hydrologic unit. A remnant area may occur when one or more islands are included into a single hydrologic unit. If the size of adjacent remnant areas is in the size range of the hydrologic unit level being defined, they should be combined into a single hydrologic unit. If the areas are relatively small, they should be included within a larger, adjacent hydrologic unit.

4.7 Non-contributing Areas

Drainage areas that do not flow toward the outlet of any hydrologic unit are considered non-contributing areas (*Exhibit 3*). Such areas may be due to glaciated plains (potholes), enclosed basins, playas, cirques, depression lakes, dry lakebeds, or similar landforms. Such areas may be large enough to be designated as hydrologic units at any level of the hierarchy if they are within the size range for a given level. Once "lake hydrologic units" such as playas and dry lakebeds in non-contributing areas have been delineated at any level, it will not be further divided at the next lower hydrologic unit level. The largest non-contributing area in the U.S. is the Great Basin, which appears in Nevada, Utah, Oregon and California. This closed area is large enough to be considered as a sub-region.

Semi-confined basins contributing surface water to another area in wet years, but acting as a sink in dry years may be considered as a hydrologic unit or non-contributing area. These types of special situations need to be reviewed, coordinated and agreed upon at the state level. Assistance or consultation with climatologists or NOAA on prevailing water/precipitation regimes that may have a long-term influence on non-contributing areas should be explored.

If non-contributing areas are small and dispersed relative to the hierarchical level being delineated, or if they are scattered throughout a drainage area, they should be considered as part of the encompassing delineated hydrologic unit. Note the size of the non-contributing area in the attribute file for the hydrologic unit containing the non-contributing area. Isolated non-contributing areas larger than 3,000 acres should be delineated.

With the diversity of unique and unusual landforms across the country, the criteria for delineating non-contributing areas caused by these unusual land features cannot be fully covered in this section. Because a non-contributing area will likely vary from state to state, document the criteria used to determine non-contributing areas in the metadata file especially if a significant number of non-contributing areas are defined. Include the amount of non-contributing areas within a hydrologic unit as an attribute of the database. Delineate non-contributing areas in a consistent manner throughout the state.

4.8 Karst

The delineation of hydrologic unit boundaries in karst areas is difficult because the potential exists to attribute the "runoff" from one hydrologic unit, or portion of a hydrologic unit, to the wrong pour point. This difficulty occurs because the surface drainage pattern in karst areas is typically disrupted by sinkholes and sinking streams, making it difficult to choose a valid watershed boundary based on topography alone. Karst conduits frequently cross beneath topographically defined watershed boundaries and drainage may be routed into or out of a topographically defined hydrologic unit. Because of the presence of karst conduits, ground water and surface-water interaction is relatively direct and rapid compared to that in non-karst areas. The conduit networks transport most of the storm-water runoff and the flow is both fast and turbulent. Each conduit network drains a finite area (karst basin), and discharges to a perennial spring.

Areas within hydrologic units exhibiting sinkholes, sinking streams, springs, or cave entrances on topographic maps, or any other map symbols associated with karst, have karst hydrology. Where

geologic maps are available, even though sinkholes might not be expressed on the topographic map, any areas underlain at the near surface by soluble rocks such as limestone, dolomite, gypsum, or salt should be assumed to have karst hydrology unless proven otherwise. All hydrologic units containing karst should be noted with the modifier “KA” in the relevant hydrologic unit modifications fields “Hu_10_mod” and “Hu_12_mod” (refer to Sub-sections 7.2.9 and 7.2.13).

Karst basins contributing water to another area (overflowing on the surface or underground via conduit drainage) during high flow, but acting as a sink (wholly discharging to a perennial spring functioning as a pour point) in dry periods, may be considered as a Hydrologic Unit where their boundaries are known, or simply designated as a karst area where their boundaries are not known. Such areas may be designated as Hydrologic Units at any level of the hierarchy if they are within the size range for a given level. If areas exhibiting karst are small and dispersed relative to the hierarchical level of the Hydrologic Unit being delineated, they should be considered as part of the encompassing delineated Hydrologic Unit. Additional details regarding karst within the hydrologic unit may be noted in one of the comments files (refer to Sub-section 7.4).

4.9 Reservoirs and Natural Lakes

The delineation of hydrologic unit boundaries is often complicated by the presence of reservoirs or large natural lakes. The fact that reservoirs and lakes overshadow or hide the natural drainage system makes the delineation of hydrologic units more difficult. The way the pool area and its underlying drainage pattern is treated with respect to hydrologic units is dependent on the size of the pool area and the amount of fluctuation there is in the normal pool area. Delineation of hydrologic units involving or around reservoirs should be done using depth data (if available) and legacy channels, thus ignoring the reservoir pool. In effect, take the water away and let underwater features direct the flow. A hierarchy of three steps on how to treat these situations at reservoirs and lakes follows:

First, consider subdividing the hydrologic unit at a dam or natural spill point of the reservoir or lake. This will be dependent on other factors such as hydrologic unit size, adjoining hydrologic units, etc.

Second, boundaries should not be delineated to the reservoir's normal, average, or high pool. Since all of a reservoir's pool area should be accounted for, subdivide the hydrologic units to the legacy channel system underlying the pool area (*Exhibit 4*).

There may be exceptions to the adherence of this rule, especially where long-term permanent large-scale water bodies such as lakes and reservoirs with historically documented permanent pools exist. Some states have completed watershed delineations without using legacy channels, and where the boundaries are recognized within state law, it might be impractical to revise these boundaries for the sole purpose of conforming to the WBD.

Third, for natural lakes, consider the pool area of a hydrologic unit and adjoining hydrologic units at "normal" pool level. Tributary areas that flow directly into a lake, and of a size consistent with the hydrologic unit level being delineated, would be delineated as "classic" watersheds with an outlet at the lake edge. For a lake that is of a size consistent with the hydrologic unit level being delineated, it is appropriate to delineate the lake as a separate hydrologic unit (*Exhibit 5*). In general, tributary areas that flow directly into the lake would be encompassed in the "lake hydrologic unit". An

example of a lake hydrologic unit would be "Lake Okeechobee" in Florida.

Areas that drain into a lake, but cannot be delineated at a consistent size, should be included as part of the lake hydrologic unit unless the result of the combined unit exceeds the consistent size of other units in that level. In this circumstance, the lake would be delineated as a hydrologic unit and the adjacent slope areas would be delineated as remnant hydrologic units. These remnant hydrologic units should be subdivided, when necessary, based on hydrography and should maintain consistent size.

4.10 Diverted Waters

Make every attempt to delineate hydrologic units on natural surface water flow and natural topographic land features. Using ditches and canals to determine surface-water drainage areas should only be used when the man-made feature has permanently altered the natural flow. Many man-made drainage features in the United States were originally either perennial or intermittent channels that local government and private entities converted into a permanent drainage feature. Much of the surface drainage in these areas would “disappear” from local and state drainage maps if permanent constructed diversions were not considered when delineating hydrologic units. If the present day canal or ditch was once a legacy stream channel or has perennial flow, then it may be considered for delineation of hydrologic units. Try to avoid delineating small, local ditch systems that divert water seasonally or for irrigation of agriculture fields.

When all or part of the flow from one hydrologic unit is continuously discharged into another by constructed transbasin diversions, document the diverted flow as attributes to both the water-losing and water-gaining hydrologic units in the "Hu_10_mod" or “Hu_12_mod” field (refer to Sub-sections 7.2.9 and 7.2.13). Information on the date of the diversion, flow rates, and water rights for both the receiving and losing hydrologic units may be included in the comments info file or metadata.

A dam, diversion, or stream confluence may be used to divide a hydrologic unit into upper and lower parts. Do not adjust the location of hydrologic units due to interconnected flow from one hydrologic unit to another during high flow stages in rivers or streams. Ditches or canals that permanently alter natural flow may be treated as a stream; however, make every attempt to base hydrologic units on natural surface water flow. It is important to track diversions that move water from one hydrologic unit to another as attributes in the "Hu_10_mod" or “Hu_12_mod” field.

4.11 Coastal Areas

The delineation of hydrologic unit boundaries is often complicated in coastal areas by the presence of large estuaries, bays or sounds. The delineation of hydrologic units in coastal areas should be based on the natural flow of water due to the topography of the land, except where long-term permanent large-scale coastal water bodies exist.

The coastal guidelines apply to ocean coastal areas, non-ocean coastal areas such as the Great Lakes, and large tidal rivers such as parts of the Mississippi, Columbia and Potomac Rivers. The coastal guidelines provide a scientific basis to extend gravity-based flow through hydrographically complex coastal areas. Coastal HU's drain either to a point (as in inland HU's) or to an open-water

HU.

Because water levels in coastal water bodies can fluctuate significantly, hydrologic units should be mapped based upon submerged morphologic features including shoals, shore faces and flow channels (legacy channels). Boundaries should not be delineated to the normal, average, or high water levels of the coastal water body. In essence, ignore the water when delineating boundaries and map to the toe of the shore face, and along shoals (submerged ridges). NOAA digital raster graphic charts exist for all coastal areas of the U.S. including the Great Lakes. Use the largest scale and most recent charts that provide individual depth sounding and depth contour data. Digital tools may be used to identify open-water HU's from digital elevation models.

For a coastal body of water that is of a size consistent with the hydrologic unit level being delineated, it is appropriate to delineate the water body as a separate hydrologic unit. Areas draining into an open-water HU, but which cannot be delineated at a consistent size should be included as part of the adjacent land HU unless the result of the combined unit exceeds the consistent size of other units in that level. These remnant units should be subdivided, when necessary, based on topographic and/or hydrographic information and the need to maintain consistent size.

Delineate island HU's based on their size and geomorphic context. An island too small to be its own HU is included within an open-water HU. An island large enough to be its own HU is delineated and drains into the surrounding open-water HU or ocean. Subdivide island HU's consistent with HU size criteria. Islands located between open-water HU's or between an open-water HU and the ocean are subdivided by a boundary to associate surface flows to the two sides of the islands. This approach is applied if there is a single barrier island or a string of islands along a shoal or reef that provides the hydrologic barrier. Offshore islands or strings of islands are treated similarly if the open water between the islands and mainland is an open-water HU. The barrier concept can be applied to other geologic formations that form hydrologic barriers to flow, such as a peninsula or isthmus, etc. The seaward boundary of the hydrologic unit coverage includes the drain point of ocean inlets and the toe of the Shoreface.

5. Mapping and Delineation Process

The mapping process used to delineate hydrologic unit boundaries has typically been done using either manual or digital techniques. Hydrologic modeling techniques are being evaluated for use in streamlining and improving the delineation of hydrologic unit boundaries through the use of digital elevation data. This section briefly describes the source maps and data needed for delineation, and the manual or digital delineation processes. Either process described is acceptable providing the final hydrologic units meet the standards.

5.1 Base Maps, Map Scale and Map Accuracy

The official base map for delineating watershed and subwatershed boundaries is the USGS 1:24,000 scale topographic quadrangles. The delineation may be done using either a paper lithograph of the map, Digital Raster Graphic of the 1:24,000 scale topographic map, or the 7.5 minute Digital

Elevation Model (DEM). Digital elevation data equivalent or better to the vertical and horizontal resolutions of either the USGS 30 meter, Level 2 DEMs or National Elevation Dataset (NED) are acceptable for delineating "draft" or "preliminary" maps of hydrologic units. In Alaska and the Caribbean, USGS base maps at 1:25,000 or 1:63,360 scale may be used in the absence of 1:24,000 scale base maps.

The 10 and 12-digit hydrologic unit boundaries must be delineated and georeferenced to the USGS 1:24,000 scale base map, which meets National Map Accuracy Standards (NMAS). Adherence to these standards for accuracy, scale and map format will produce a seamless and consistent national hydrologic unit geographic coverage that:

- is in a format acceptable to the majority of data users,
- allows for efficient geospatial and attribute data exchange between agencies,
- supports multi-agency planning programs, models, database and GIS analyses,
- is consistent with the format and scale of most agency geospatial databases,
- registers with digital orthoimagery and other similar geospatial databases.

5.2 Source Maps

This section specifies the types of source maps in either paper or digital form to be used to make the hydrologic unit delineations. The source data described is not an all-inclusive list. Development of some hydrologic unit boundaries will use new or revised data from other sources. Each source map or dataset used must be referenced in the metadata. Record the date and accuracy level of the source data particularly for elevation values and hydrography data.

5.2.1 Base Maps

Use the printed copies of the USGS topographic quadrangle maps. Most 7.5 minute topographic maps are published at 1:24,000 (1" = 2,000'), but some are printed at 1:25,000 scale (1"= 2083') or 1:20,000 (1"=1667'). Do not use "blueprints" or similar copies. USGS state base maps at 1:500,000 scale and the USGS 1:100,000 scale topographic series maps can be used for preliminary mapping of hydrologic unit boundaries.

5.2.2 Hydrologic Unit Maps

Obtain a digital or printed copy of the USGS 8-digit state hydrologic unit map, and hydrologic unit maps prepared by NRCS, Forest Service, and state agencies. The USGS 8-digit state hydrologic unit maps done at the fourth level of detail provide an appropriate reference to begin delineating the fifth and sixth level hydrologic units.

Use these maps to determine the general location of the new or redefined watershed or subwatershed hydrologic units, review the existing coding system, and determine the level of mapping complexity needed.

5.2.3 Reference Maps

The following reference maps may be helpful in delineating hydrologic boundaries:

- ? county drainage,
- ? as-built plans including diversions and ditches,
- ? direction of flow drainage,
- ? NOAA nautical charts, (use the most recent editions of the charts at map scales of 1:40,000 and greater that display the bathymetric data for coastal waters.)
- ? storm sewer map,
- ? land cover map,
- ? soil surveys,
- ? orthophotos or aerial photographs,
- ? major land resource area map,
- ? watershed project maps.

Retain as a permanent record all maps, measurement data, and other source materials used to determine the location of hydrologic units.

5.2.4 Digital Data

Digital geospatial data, such as the USGS 1:24,000 scale Digital Raster Graphics (DRGs) (<http://www.lighthouse.nrcs.usda.gov/gateway/gatewayhome.html>) can be used for on-screen digitizing of hydrologic units, and for clarifying line position when using other digitizing methods. Digital Elevation Models (DEMs) are needed if the digital-modeling method is used to delineate and digitize the hydrologic unit boundaries. The Environmental Protection Agency (EPA) river reach files and the National Hydrography Dataset are other useful databases for identifying primary tributaries within an area being subdivided. The NOAA nautical charts are also available in digital raster form. Some federal and state agencies already have basin and sub-basin units delineated and available in digital form.

5.3 Map Delineation Process

The hydrologic unit mapping process can be done using either manual or digital methods. Within each of the two methods, there are slightly different procedures for completing the delineation, mapping, and digitizing. Use of either process is acceptable providing the watersheds and subwatersheds geospatial database is georeferenced to the USGS 1:24,000 scale topographic base map that meets NMAS.

Drainage divides are usually determined by bisecting ridges, saddles, and contour lines of equal elevation. Hydrologic unit boundaries follow the middle of the highest ground elevation or halfway between contour lines of equal elevation. The hydrologic unit boundary will cross perpendicular to the stream channel at the outlet. The hydrologic unit boundary has only one outlet point, except in the case of remnant, deltas, coastal, and lakefront areas. Hydrologic unit boundaries cannot be streams or rivers (see Section 4.10 on coastal and non-tidal sections of streams and rivers).

Use the topographic map detail (contours, elevations, drainage patterns) to interpret and delineate

the hydrologic units. In coastal areas, use the NOAA nautical charts. In areas of flat terrain, interpolation between contours may be done by reference to trails, old roads, or firebreaks in forested areas, all of which frequently follow drainage divides. More detailed information may be obtained from local highway or street profiles, examination of aerial photographs, county drainage or ditch-canal maps, and ground reconnaissance by local employees.

In urban areas, use elevation change rather than relying on storm sewer maps to maintain consistency in delineating according to natural features and surface water flow.

Some state hydrologic unit maps of 8-and 10-digit boundaries were either done at different map scales or on inaccurate base maps. These maps are not acceptable for digitizing, but are good to use as a general reference in relocating the 10-digit hydrologic units onto the accurate 1:24,000 topographic maps.

Hydrologic unit boundaries must edge-match at state boundaries. States or regions should consider delineating hydrologic units within an 8-digit sub-basin at the same time, and not stop at state boundaries. If this is not possible, adjoining states need to coordinate the delineation of hydrologic unit boundaries at state boundaries.

There may be situations where all six levels of hydrologic units cannot be delineated because of impractical reasons or due to a lack of well defined drainage conditions such as extensive swamp areas, lava fields or clusters of small islands.

5.4 Manual Method

Where hydrologic units have not been previously mapped onto the USGS 1:24,000 topographic maps, begin by mapping or transferring the sub-basin (8-digit) boundaries onto the USGS 1:100,000 scale topographic lithographic maps. If the locations of any 8-digit boundaries are questionable or need to be re-located to be more hydrologically correct, notify the USGS. Obtain assurance from the USGS that proposed changes are acceptable before making the adjustment or revision. The mapping overview at the 1:100,000 scale illustrates the level of detail, and shows which 1:24,000 topographic maps will be needed to map the watersheds and subwatersheds. Draw boundaries of watersheds within the sub-basin at the 1:100,000 scale. Completing this process provides a good overview of where the sub-basin is located and sets the stage for the more precise delineation of watersheds and subwatersheds.

Transfer the sub-basin and watershed boundaries from the 1:100,000 topographic maps onto the USGS 1:24,000 topographic maps. Locate the boundaries on the 1:100,000 map, and visually delineate boundaries onto the 1:24,000 scale topographic maps. When transferring the boundaries, refine and adjust the boundary location to fit the more detailed contour intervals and drainage patterns on the 1:24,000 topographic maps. After the 8-and 10-digit hydrologic units are delineated, add the 12-digit subwatersheds to the map, and code the hydrologic units. Sub-basin (8-digit) and watershed (10-digit) boundaries previously mapped on smaller-scale state and national base maps cannot be merely transferred to the larger scale topographic maps for this task.

5.5 Digital Methods

Improvements in GIS software and availability of geospatial data offer other alternatives for

hydrologic unit development. Two different digital methods are summarized below.

5.5.1 On-Screen Mapping and Digitizing

Delineate and digitize "DRAFT" 10-digit watersheds at 1:100,000 scale. After the watershed delineation is completed, the next step is to develop the subwatershed coverage by sub-basin, and refine the locations of the 8- and 10-digit boundaries onto the 1:24,000 scale USGS topographic maps. To accomplish this, develop a reference plot for each 8-digit sub-basin showing DEM derived contour data, streams, 7.5 minute topographic quad boundaries, quad names, and 10-digit boundaries and codes. Plot a second worksheet for each 10-digit watershed within the sub-basin showing contours, streams, 10-digit boundaries and codes. Sketch 12-digit boundaries with subwatershed codes on the individual 10-digit worksheets. Use the worksheet as a visual reference for on-screen delineation and digitizing onto the 1:24,000 scale DRGs.

Do not use existing digital hydrologic unit databases developed from smaller-scale state or national base maps with the 1:24,000 scale USGS topographic maps. Overlaying or digitally combining digital data developed from small-scale maps onto larger scale maps will result in differences in line location of the same features. The boundary locations must be re-mapped and digitized to conform to the more accurate and detailed topographic maps.

For over-water boundaries in coastal areas, map a vector line coverage for the toe of the shore face and shoal lines using on-screen digitizing from NOAA digital raster nautical charts (Mercator projection). Subsequently transfer and re-project the line coverage to overlay USGS DRGs to complete the over-land hydrologic boundaries.

5.5.2 Hydrologic Modeling from Digital Elevation Models

GIS, image processing and hydrologic modeling applications make use of DEMs to represent landform features and drainage network patterns. DEMs are available in different horizontal and vertical resolutions. Digital elevation data equivalent or better to the vertical and horizontal resolutions of either the 30 meter, Level 2 DEMs or National Elevation Dataset (NED) (<http://edcnts12.cr.usgs.gov/ned/>) can be used to develop a "draft" or "preliminary" delineation of hydrologic units, which need to be further refined. DEMs or NED are combined with other geospatial data such as EPA river reach files and hydrography in a GIS to simulate drainage networks, stream courses and direction-of-flow by applying hydrologic models. Maps generated from digital hydrography data with flow direction arrows are also helpful in delineating hydrologic units.

Depending upon the modeling techniques, data resolution, data consistency, software applications, and other characteristics, the DEMs and NED will most likely provide a generalized depiction of landforms, especially in areas of moderate topographic variations or flat areas. For this reason, all DEM and NED established boundaries need to be independently checked on 1:24,000 DRGs and reviewed closely. A detailed description of the source elevation model must be documented in the metadata.

Apply a similar modeling and review process for the 30 meter pixel size bathymetric DEMs available for major estuaries and sounds nationally from NOAA.

5.6 Updating and Revising Hydrologic Units

Priority should be given to resolving any major revisions to 8-digit boundaries as soon as possible. Many existing hydrologic data sets, plus many more under development will be affected by significant revisions. Minor revisions of existing 8-digit boundaries are to be expected in order to place the boundaries properly on 1:24,000-scale maps. These are not considered major revisions and do not require prior review by USGS. Coordinate the revision of hydrologic units with other cooperating agencies.

Reasons for updating or revising hydrologic unit boundaries may be necessary as a result of a natural phenomena or significant man-made landform modifications. Some examples include the removal of a dam, earthquakes, new reservoirs, man-made embankments or levees, volcanic eruptions, massive landslides, hurricane damage, etc. The identification of errors in the original digitizing work may also lead to an update. Example of major revisions would include those that place entire stream reaches (not small pieces of headwater reaches) in different 8-digit units, or those that recode contiguous areas approximating or exceeding the size of 6th level units (10,000 to 40,000 acres).

The 8-digit sub-basin boundaries have been used and referenced so extensively in water resource activities nationwide that major changes to them should occur only in cases of major delineation error or significant landform changes due to natural phenomena or man-made modifications. Notify the USGS if the locations of 8-digit boundaries are questionable or need to be re-located to be more hydrologically correct. If an existing 8-digit sub-basin is unusually large or has multiple outlets each exceeding the range of the normal 8-digit sub-basin, consider sub-dividing the 8-digit sub-basin into more than one 8-digit sub-basin. Obtain assurance from the USGS that proposed changes are acceptable before making the revision to 8-digit sub-basins. When hydrologic unit boundaries have major revisions, update the area measurements, and note any significant revisions as "revised" when the new data is released. Keep a record of all changes to the 8-digit sub-basins in your office.

6. CODING AND NAMING

6.1 Hydrologic Unit Levels

The six different levels of hydrologic units are shown below and in *Appendix A, Exhibit 1*.

Hydrologic Unit Level	Name	Digits	Size	Units
1	Region	2	Average: 177,560 square miles	21
2	Sub-region	4	Average: 16,800 square miles	222
3	Basin	6	Average: 10,596 square miles	352
4	Sub-basin	8	Average: 703 square miles	2,149
5	Watershed	10	63-391 square miles (40,000-250,000 acres)	22,000 (estimate)
6	Subwatershed	12	16-63 square miles (10,000-40,000 acres)	160,000 (estimate)

6.2 Coding Watersheds and Subwatersheds

Do not change the numbering of the 8-digit sub-basin codes as they were officially established by the ACWI in the 1970's. Assign a new unique numbered code to each watershed and subwatershed. Maintain the 2-digit field length for successive 5th and 6th-level watersheds and subwatersheds to be consistent with the coding pattern established in the 1970's by interagency water data committees. Coordinate the coding within a sub-basin across state boundaries.

Do not complicate the coding of hydrologic units by trying to code hydrologic units as to their complete or partial presence within a county or presence within two or more counties or states. The approach is to number the hydrologic units sequentially beginning upstream and proceeding downstream. For example, start at the uppermost end of the drainage and code the first watershed as 9908020301, code the next watershed downstream as 9908020302.

A sample numbering of hydrologic units:	<u>Level</u>
First 2 fields are the Region ----- 01	1
Next 2 fields are the Sub-region ----- 0108	2
Next 2 fields are the Basin ----- 010802	3
Next 2 fields are the Sub-basin ----- 01080204	4
Next 2 fields are the Watershed ----- 0108020401	5
Next 2 fields are the Subwatershed ----- 010802040101	6

6.3 Watershed and Subwatershed Naming Protocol

The numeric Hydrologic Unit Code is the primary, unique identifier for each hydrologic unit, however, the numeric identifier alone makes it difficult to relate a hydrologic unit to a geographic area. Naming the watersheds and subwatersheds adds local and geographic identity to the hydrologic unit, and is recommended for better identifying and understanding the geographic location of the hydrologic unit. Hydrologic units are usually named after significant or prominent hydrographic features in an area, however, hydrologic units may be named after non-hydrographic features if none exists or if better understood by the users and public.

Make every attempt to identify each watershed and subwatershed with a unique name within the area being subdivided. It is desirable to maintain consistency when assigning a name to these hydrologic units. Use the following suggested guidelines for naming only the watersheds (5-digit) and subwatersheds (6-digit). Do not change the names of the 1st, 2nd, 3rd and 4th level hydrologic units. It is recommended to use the name of the major hydrographic feature within the hydrologic unit from the Geographic Names Information System (GNIS) of the USGS, in cooperation with the U.S. Board on Geographic Names (BGN)

<http://mapping.usgs.gov/www/gnis/bgn.html>, which can be found at <http://mapping.usgs.gov/www/gnis>. Geographic names may also be taken from the USGS 1:24,000 topographic quadrangles or National Hydrography Dataset.

1. Assign each hydrologic unit with a unique name that relates to the major water feature within the polygon or the major water body it contributes to. Examples are Hoquiam River; Crescent Lake; Admiralty Inlet; Sequim Bay; Grays Harbor.

2. If primary water features exist within equivalent level hydrologic units and have the same name, use the primary water feature for each hydrologic unit modified by appending the name of the receiving water body. For example, Drift Creek-Siletz River, or Drift Creek-McKenzie River.

3. Name the hydrologic units according to the name of the major water features including: rivers, creeks, sloughs, lakes, reservoirs, bays, inlets, harbors, and coves. Stream names are the preferred name to assign to the polygon. Use water body names to name polygons when the water body is the dominant feature. Examples: Admiralty Inlet; Grays Harbor; Ozette Lake; Sequim Bay.

4. Assign the hydrologic unit the name of the mainstem river, at the outlet of the hydrologic unit wherever possible.

5. End each hydrologic unit name with one of the following words spelled out in its entirety: "River", "Creek", "Branch", "Run", "Draft", "Swamp", "Fork", "Slough", "Lake", "Bay", "Frontal", "Reservoir", "Inlet", "Channel", "Harbor", "Cove", "Headwaters", "Sea", "Ocean", "Bayou", "Estuary", "Wash", "Draw", "Upper", "Middle", "Lower".

6. Assign hydrologic unit names by fully spelling out the name. Avoid abbreviations such as N., S., Fk., R., Res., etc.

7. When a major river is subdivided into multiple hydrologic units along the mainstem river, the preferred naming convention is “Headwaters” “Upper”, “Middle”, or “Lower”.

8. If a mainstem river is subdivided into more than three hydrologic units, do not use the “Upper”, “Middle” and “Lower” naming convention. Use the standard naming protocol. If the name includes the name of a primary tributary or primary hydrologic feature, separate the names with a hyphen; e.g., Upper Willamette River-Deep Creek.

9. Use of the word “of” is appropriate to shorten the naming convention of tributaries sharing the same name of the mainstem river, e.g., North Fork of the Willamette River, Upper North Fork of the Coast Fork of the Willamette River.

10. Use of the term “Frontal” is reserved for coastal and lake areas that include multiple, non-convergent rivers associated with frontal hydrologic units. Name the hydrologic units nested within “Frontal” polygons in sequence from north to south or east to west, depending on the orientation of the hydrologic unit. For example, Squirrel Creek-Chesapeake Bay Frontal.

6.4 Coding at International Borders

Code watersheds and subwatersheds by beginning the coding in the uppermost areas according to the criteria in Section 6.2.

7. GEOSPATIAL DATA STRUCTURE

7.1 Data Capture and Processing

The vector data structure is the required method for the hydrologic unit geospatial database. The line segments and hydrologic unit codes for each data set must be topologically structured. The following attribute structure was developed for the national review and verification process and to create one national seamless dataset. Several amls and ArcView extensions that may help in populating the attribute table can be found at http://www.fw.nrcs.usda.gov/huc_data.html. The attribute structure of the national dataset may be altered once it is converted into the WBD.

7.1.1 Digitizing

Digitize hydrologic unit boundaries as closed area polygons. Data shall be captured as double precision, and digitized from the delineations made on the 1:24,000 USGS topographic maps. Digitize hydrologic unit boundaries as arcs and close to form area polygons.

7.1.2 Post Digitizing Processing

All line work not required for defining polygons (such as dangles) shall be removed. Eliminate all sliver polygons by assigning their areas to the appropriate true polygon. Only one label shall be assigned to each polygon. Coverages shall be clean and topologically correct.

7.2 Polygon Attribute Scheme

Attribute field (item) names need to be spelled exactly as shown and in the order specified. Required attributes must be populated unless fields are optional, in those cases, leave the field blank. The attribute schema is illustrated for Environmental Systems Research Institute (ESRI) software¹. If another software is being used other than ArcInfo or ArcView, please follow the ArcInfo format. For field width in ArcView, please create the fields according to the width specified under "Output" in the descriptions below. All the fields listed below are required in each state dataset, but, a state may add additional fields to their own dataset. If there are any questions, contact the USDA-NRCS National Cartography & Geospatial Center (NCGC) for assistance.

7.2.1 Eight Digit Hydrologic Unit Code - (REQUIRED)

A unique 8-digit code from the USGS map series "Hydrologic Unit Maps". Use the existing code for the sub-basin where the subwatershed resides; do not change this code. The same number should be used in every record that pertains to a subwatershed that resides within the same 8-digit sub-basin.

<u>Item name</u>	<u>Width</u>	<u>Output</u>	<u>Type</u>	<u>N.Dec.</u>	<u>Example</u>
Huc_8	8	8	C	-	01080201

7.2.2 Ten Digit Hydrologic Unit Code - (REQUIRED)

This field provides a unique 10-digit code for each watershed. Add two digits to the end of the existing 8-digit code, therefore resulting in a 10-digit number. This same number should be used in every record that pertains to a subwatershed that resides within the same 10-digit watershed.

<u>Item name</u>	<u>Width</u>	<u>Output</u>	<u>Type</u>	<u>N.Dec.</u>	<u>Example</u>
Huc_10	10	10	C	-	0108020103

7.2.3 Twelve Digit Hydrologic Unit Code - (REQUIRED)

This field provides a unique 12-digit code for each subwatershed. Add two digits to the end of the existing 10-digit code, therefore creating a 12-digit number.

<u>Item name</u>	<u>Width</u>	<u>Output</u>	<u>Type</u>	<u>N.Dec.</u>	<u>Example</u>
Huc_12	12	12	C	-	010802010310

¹ Any use of trade, product, or firm names in this document is for descriptive purposes only and does not imply endorsement by the U.S. Government.

7.2.4 Acres - (REQUIRED)

Area of subwatershed including non-contributing areas calculated to acres as a whole number, no decimals. The "Acres" field needs to be calculated from the "Area" field.

<u>Item name</u>	<u>Width</u>	<u>Output</u>	<u>Type (ArcView)</u>	<u>N.Dec.</u>	<u>Example</u>	
Acres	8	12	F	N	0	26739

7.2.5 States - (REQUIRED)

The "States" field needs to include the names of all state(s) that the subwatershed falls within. Use the 2-digit postal abbreviation in upper case and sort the state(s) in alphabetical order. If using more than one abbreviation, separate with a comma with no space after the comma.

<u>Item name</u>	<u>Width</u>	<u>Output</u>	<u>Type</u>	<u>N.Dec.</u>	<u>Example</u>
States	11	11	C	-	KS,MO,OK

7.2.6 Non-Contributing Area - (FIELD REQUIRED, ATTRIBUTES OPTIONAL)

Drainage areas that do not flow toward the outlet of any hydrologic unit are considered non-contributing. If a non-contributing area is on the boundary between two or more hydrologic units, determine the low point along the non-contributing area boundary. The non-contributing area should be associated with the hydrologic unit adjacent to the low point on the boundary. This attribute should be the total of the non-contributing areas within a hydrologic unit calculated in acres.

<u>Item name</u>	<u>Width</u>	<u>Output</u>	<u>Type (ArcView)</u>		<u>N.Dec.</u>	<u>Example</u>
Ncontrb a	8	12	F	N	0	357

7.2.7 Fifth Level Downstream Hydrologic Unit Code - (FIELD REQUIRED, ATTRIBUTES OPTIONAL)

Populate this field with the 10-digit code of the 5th level hydrologic unit that is receiving the majority of the flow from the watershed that the 6th level HU falls within. Outlets created by ditching or other artificial drainage are not to be considered for this field. If an HU flows into an ocean or the Gulf of Mexico populate this field with "OCEAN" and if a HU flows into one of the Great Lakes use the term "LAKE". If a HU flows across international borders use "CANADA" or "MEXICO" depending on which country the HU drains into. If an HU is a closed basin, then populate this record with the term "CLOSED BASIN".

<u>Item name</u>	<u>Width</u>	<u>Output</u>	<u>Type</u>	<u>N.Dec.</u>	<u>Example</u>
Hu_10_ds	10	10	C	-	1710020504

7.2.8 Fifth Level Hydrologic Unit Name - (FIELD REQUIRED, ATTRIBUTES OPTIONAL)

This field is for officially recognized names only. Populate this field by following the directions in subsection 6.3 "Watershed and Subwatershed Naming Protocol". Populate this field with the identical name for all 6th level hydrologic units that fall within the same 10-digit HU. The name used to attribute the watershed should be used only once within a 4th level unit.

<u>Item name</u>	<u>Width</u>	<u>Output</u>	<u>Type</u>	<u>N.Dec.</u>	<u>Example</u>
Hu_10_name	80	80	C	-	Upper Blue River

7.2.9 Fifth Level Hydrologic Unit Modifications - (REQUIRED)

This field should identify any type of modifications to natural overland flow that alters the location of the hydrologic unit boundary for a 10-digit watershed. In the attribute field, identify from most significant to least significant modification(s). Use one or more of the following abbreviations in uppercase to identify your modification(s). If using more than one abbreviation, separate with a comma with no space after the comma.

SC - Stormwater Canal	ID - Irrigation Ditch	IT - Interbasin Transfer
BC - Barge Canal	SD - Stormwater Ditch	PD - Pipe Diversion
CD - Channel Diversion	NC - Non-Contributing	KA - Karst
LE - Levee	NM - No Modifications	OC - Overflow Channel
DM – Dam at outlet or HU boundary		OT - Other

<u>Item name</u>	<u>Width</u>	<u>Output</u>	<u>Type</u>	<u>N.Dec.</u>	<u>Example</u>
Hu_10_mod	20	20	C	-	CD,NC,ID

7.2.10 Fifth Level Hydrologic Unit Type - (REQUIRED)

Populate this field with the hydrologic unit type from the list provided that most closely identifies the watershed. Use any of the one-digit abbreviations in uppercase that is provided in the list.

S - "Standard" hydrologic unit - Any land HU with drainage flowing to a single outlet point, excluding non-contributing areas. This includes areas or small triangular wedges between adjacent HU's that remain after classic hydrologic units are delineated. Some examples include "true", "classic", "composite", and "remnant" hydrologic units.

C - "Closed Basin" hydrologic unit – A drainage area that is 100% non-contributing. This means all surface flow is internal, no overland flow leaves the hydrologic unit through the outlet point.

F - "Frontal" hydrologic unit - Areas along the coastline of lakes, oceans, bays, etc. that have more than one outlet. These HU's are predominantly land with some water areas at or near the outlet(s).

W - "Water" hydrologic unit - Hydrologic units that are predominantly water with adjacent land areas, ex. lake, estuaries, harbors.

I - "Island" hydrologic unit - A hydrologic unit that is one or more islands and adjacent water out to the toe of the shore face.

U - "Unclassified" hydrologic unit - A hydrologic unit that can't be defined or doesn't fit into one of the types that have been listed.

Item name	Width	Output	Type	N.Dec.	Example
Hu_10_type	1	1	C	-	S

7.2.11 Sixth Level Downstream Hydrologic Unit Code - (FIELD REQUIRED, ATTRIBUTES OPTIONAL)

Populate this field with the 12-digit code of the 6th level hydrologic unit that is receiving the majority of the flow from the subwatershed. Outlets created by ditching or other artificial drainage are not to be considered for this field. If a HU flows into an ocean or the Gulf of Mexico populate this field with "OCEAN" and if a HU flows into one of the Great Lakes use the term "LAKE". If a HU flows across international borders use "CANADA" or "MEXICO" depending on which country the HU drains into. If an HU is a closed basin, then populate this record with the term "CLOSED BASIN".

Item name	Width	Output	Type	N.Dec.	Example
Hu_12_ds	12	12	C	-	171002050402

7.2.12 Sixth Level Hydrologic Unit Name - (FIELD REQUIRED, ATTRIBUTES OPTIONAL)

This field is for officially recognized names only. Populate this field by following the directions in subsection 6.3 "Watershed and Subwatershed Naming Protocol". The name used to attribute the subwatershed should be used only once within a 5th level unit.

<u>Item name</u>	<u>Width</u>	<u>Output</u>	<u>Type</u>	<u>N.Dec.</u>	<u>Example</u>
Hu_12_name	80	80	C	-	Drift Creek-Big Bear River

7.2.13 Sixth Level Hydrologic Unit Modifications - (REQUIRED)

This field should identify any type of modifications to natural overland flow that alters the location of the hydrologic unit boundary for a 12-digit subwatershed. In the attribute field, identify from most significant to least significant modification(s). Use one or more of the following abbreviations in uppercase to identify your modification(s). If using more than one abbreviation, separate with a comma with no space after the comma.

SC - Stormwater Canal	ID - Irrigation Ditch	IT - Interbasin Transfer
BC - Barge Canal	SD - Stormwater Ditch	OC - Overflow Channel
PD - Pipe Diversion	CD - Channel Diversion	NC – Non-Contributing
KA - Karst	LE – Levee	NM – No Modifications
Dm – Dam at outlet or HU boundary		OT - Other

<u>Item name</u>	<u>Width</u>	<u>Output</u>	<u>Type</u>	<u>N.Dec.</u>	<u>Example</u>
Hu_12_mod	20	20	C	-	SD,KA,PD

7.2.14 Sixth Level Hydrologic Unit Type - (REQUIRED)

Populate this field with the hydrologic unit type from the list provided that most closely identifies the subwatershed. Use any of the one digit abbreviations in uppercase that is provided in the list.

S - "Standard" hydrologic unit - Any land HU with drainage flowing to a single outlet point, excluding non-contributing areas. This includes areas or small triangular wedges between adjacent HU's that remain after classic hydrologic units are delineated. Some examples include "true", "classic", "composite", and "remnant" hydrologic units.

C - "Closed Basin" hydrologic unit – A drainage area that is 100% non-contributing. This means all surface flow is internal, no overland flow leaves the hydrologic unit through the outlet point.

F - "Frontal" hydrologic unit - Areas along the coastline of lakes, oceans, bays, etc. that have more than one outlet. These HU's are predominantly land with some water at or near the outlet(s).

W - "Water" hydrologic unit - Hydrologic units that are predominantly water with adjacent land areas, ex. lake, estuaries.

I - "Island" hydrologic unit - A hydrologic unit that is one or more islands and adjacent water out to the toe of the shore face.

U - "Unclassified" hydrologic unit - A hydrologic unit that can't be defined or doesn't fit into one of the types that have been listed.

<u>Item name</u>	<u>Width</u>	<u>Output</u>	<u>Type</u>	<u>N.Dec.</u>	<u>Example</u>
Hu_12_type	1	1	C	-	C

7.2.15 ArcInfo (.pat) and ArcView Polygon Format

Item name	Width	Output	Type (ArcView w)	N.Dec.	Example	
Huc_8	8	8	C	-	01080201	
Huc_10	10	10	C	-	0108020103	
Huc_12	12	12	C	-	010802010310	
Acres	8	12	F	N	0	26739
States	11	11	C	-	KS,MO,OK	
Ncontrb_a	8	12	F	N	0	357
Hu_10_ds	10	10	C	-	1710020504	
Hu_10_name	80	80	C	-	Upper Blue River	
Hu_10_mod	20	20	C	-	CB,NC,ID	
Hu_10_type	1	1	C	-	S	
Hu_12_ds	12	12	C	-	171002050402	
Hu_12_name	80	80	C	-	Drift Creek-Big Bear River	
Hu_12_mod	20	20	C	-	SD,KA,PD	
Hu_12_type	1	1	C	-	C	

7.3 Linework Attribute Scheme

This attribute table provides descriptive information on each boundary line. Attribute field (item) names need to be spelled exactly as shown and in the order specified. If using ArcView to create the dataset, develop all your hydrologic unit boundaries and go through the instate review process, then convert to ArcInfo and create line (.aat) attribute table by using the "build" command. Then populate the (.aat) attribute table in either ArcInfo or ArcView. If using another software create an attribute table that is identical to the one shown. If there are any questions, contact the National Cartography & Geospatial Center for assistance.

7.3.1 Hydrologic Unit Level - (REQUIRED)

This field provides the means to create cartographically pleasing maps. Populate this field with the highest hydrologic unit level (smallest number) for the line (arc) represented by the record. Record the level using numbers 1 through 6 representing each level with 1 being the highest and 6 the lowest level. An example would be if a line represents a region, subregion, basin, subbasin, watershed, and subwatershed boundary, then this cell would be populated with a 1 (Region). Example two would be if a line is a subbasin, watershed, and subwatershed boundary, then the cell would get a 4 (Subbasin). Use one of the levels provided in the list below.

<u>Level</u>	<u>Digit#</u>	<u>Name</u>
1	2	Region
2	4	Subregion
3	6	Basin
4	8	Subbasin
5	10	Watershed
6	12	Subwatershed

<u>Item Name</u>	<u>Width</u>	<u>Output</u>	<u>Type</u>	<u>N.Dec.</u>	<u>Example</u>
Hu_level	1	1	I	-	6

7.3.2 Line Spatial Data Source - (REQUIRED)

The Linesource should indicate the base map source(s) used to delineate at 1:24,000 scale. Populate the field using one of the standardized code(s) listed below in uppercase. If using more than one code, separate with a comma with no space after the comma.

TOPO24 - Delineation from hardcopy 1:24,000 scale topographic maps
 TOPO25 - Delineation from hardcopy 1:25,000 topographic maps, only Alaska and Caribbean
 TOPO63 - Delineation from hardcopy 1:63,360 topographic maps, only Alaska and Caribbean
 DRG24 - Delineation from 1:24,000 scale Digital Raster Graphics
 DRG25 - Delineation from 1:25,000 Digital Raster Graphics, only Alaska and Caribbean
 DRG63 - Delineation from 1:63,360 Digital Raster Graphics, only Alaska and Caribbean
 DEM10 - Derived from 10 meter Digital Elevation Model
 DEM30 - Derived from 30 meter Digital Elevation Model
 NED30 - Derived from 30 meter National Elevation Dataset Model
 EDNA30 - (formally NED-H), derived from 30 meter Elevation Derivatives for National Applications
 BATH"scale" (ex. BATH24) - Interpreted from NOAA 1:24,000 scale bathymetric data
 HYPSO"scale" (ex. HYPSO24)- Delineated from 1:24,000 scale contour data
 ORTHO"scale" (ex. ORTHO12) - Interpreted from 1:12,000 scale Ortho-imagery
 DEDEM10 - Drainage enforced 10 meter Digital Elevation Model
 DEDEM30 - Drainage enforced 30 meter Digital Elevation Model
 GPS - Derived from Global Positioning System
 LIDAR - Derived from LIDAR
 IFSAR - Derived from IFSAR data
 OTH - Other
 UNK - Unknown

All other reference and source maps not listed should be noted in the metadata.

<u>Item name</u>	<u>Width</u>	<u>Output</u>	<u>Type</u>	<u>N.Dec.</u>	<u>Example</u>
Linesource	20	20	C	-	DEM30,DRG24,GPS

7.3.3 Metadata ID Number - (REQUIRED)

Metadata ID is a code that identifies which metadata file applies to the arc. In many cases there will only be one metadata file. However, in some cases more than one metadata file may be created to identify different groups and/or procedures used to produce the lines. These separate metadata files may be identified for each separate arc.

The metadata ID should be a 4-character code starting with the 2-letter state postal code, followed by a 2-digit sequence number. For example "OK01", "ID02", etc.

Item name	Width	Output	Type	N.Dec.	Example
Meta_id	4	4	C	-	OK01

7.3.4 ArcInfo Line (.aat) Attribute Format

Item name	Width	Output	Type	N.Dec.	Example
Hu_level	1	1	I	-	6
Linesource	20	20	C	-	DEM30,DRG24,GPS
Meta_id	4	4	C	-	OK01

7.4 Comments Info Files (FILE OPTIONAL)

Separate info files where comments can be stored for the polygons or lines. Each file should contain two items, a record number that relates to the .aat or .pat record number (cover#) and an 80-character field called "Comment". The info file naming convention is: 2-digit state postal abbreviation_com for either the polygon or line comments info file.

Example - MO_com_poly

MO_com_line

Item name	Width	Output	Type	N.Dec.	Example
Mo_hu12#	4	5	B	-	5
Comment	80	80	C	-	Levee influenced location of boundary

7.5 File Format

The file format criteria shown below are required for final verification of the hydrologic units, and to merge individual state coverage's into a seamless national database. The hydrologic unit data files are to be provided for verification in ArcInfo coverage format unless this is not available, then

ArcView shapefile. These standards do not cover file formats for data distribution. Formats for distributing data are the responsibility of the data provider and data user.

7.5.1 File Names

The dataset naming convention for verification is: 2-digit state postal abbreviation_hu12

Arc coverage example: oh_hu12

ArcView file example: oh_hu12.shp

7.5.2 Projection of Coverage

When the state is creating the digital dataset, the projection that works best for a particular state may be used. However, when the datasets is submitted for national verification and archival it must be provided in Geographic or the dominant UTM zone for the state, and DATUM as NAD83. Provide ArcInfo coverages as double precision. Note all projection information in the metadata.

A readme file should accompany ArcView shapefiles and contain projection, datum, zone, etc. types of data. The readme file may also contain other pertinent information that would be useful during QA/QC and verification review. Information may also be provided in a .prj file as long as it contains all the projection and datum information.

Coordinate System Descriptions

Projection:	Geographic		
Datum:	NAD83		
Units:	Decimal Degrees	Spheriod	GRS1980

or

Projection:	UTM		
Zone:	17		
Datum:	NAD83		
Units:	Meters	Spheroid	GRS1980

7.5.3 Exporting and Compression

If delivering an Arc coverage, use the “export” command to produce a coverage with an ".e00" extension. Use compression software that is suitable for UNIX and NT/PC environments.

Examples:

1. Export as oh_hu to oh_hu.e00, copy into a new directory along with the metadata, and then zip these files into a single file having a .zip file extension.
2. Copy the metadata and ArcView shape files (.shp, .dbf, .sbx, .sbn, .shx) to a new directory, then zip these files into a single file having a .zip file extension.

7.6 Data Distribution

7.6.1 Verification Related Distribution

Post the compressed data to an ftp site as “binary” type. Notify the national contact (refer to Subsection 8.3) having responsibility for data verification and archival. The coverage may also be written to a CDROM and mailed to the national contact for verification and archival.

7.6.2 Public Distribution

These standards do not cover the distribution of data to users following verification. Distribution formats and media types at that point in time are agreed upon between the data provider and data user.

8. QUALITY ASSURANCE AND QUALITY CONTROL

8.1 Quality Control

Ideally, hydrologic units are delineated using an interagency process. However, it may be necessary for one agency to take the lead in developing and certifying the hydrologic unit boundaries. Hydrologic unit boundaries shall be reviewed by the originating agency and/or designated members of an Interagency Hydrologic Unit Group within the state, typically a hydrologist, natural resource specialist, or GIS Specialist with background and experience with hydrologic units. The originating agency should invite representatives of the Interagency Hydrologic Unit Group, and or regional/local parties to participate in the development and review of delineations before the data is submitted for national verification and release to the public. The database should go through an extensive review process by the state representatives before submitting for verification.

It is recommended that reviews and edit checks be conducted throughout the delineation process. At a minimum, edit checks should be made after the watersheds and subwatersheds are delineated, mapped, and digitized. See the editing checklist sample shown in Appendix C for review documentation.

8.2 Editing Checklist

Below is a recommended list of items to be checked during the delineation and digitizing process.

This is not an inclusive list, but covers most items to be verified.

- Agencies should work directly with their adjoining state counterparts to assure the hydrologic unit boundaries are edge-matched at state boundaries, and coding and sizing is consistent. This is necessary for maintaining a consistent national database of hydrologic units. Resolve differences in hydrologic unit delineations and coding at state boundaries before the data is submitted for agency verification and distribution to the public.
- Hydrologic units that were difficult to delineate in areas such as flat terrain may need to be field checked. Make notes on a checklist about how certain boundaries were established so they can be added to the attribute table.
- Use local sources to resolve the location of questionable boundaries. Make notes where local knowledge supersedes source maps and add this information to the attribute table.
- Check the coding system for correctness, duplication or missing codes. Coding of hydrologic units must be consistent within a sub-basin covering more than one state. Each polygon must have a label.
- Check the attribute table, make sure the fields are completed correctly with no empty fields.
- Make sure the "ACRES" field is calculated from the "Area" field with no decimal places.
- Verify the "State" field is labeled correctly with the 2-digit postal abbreviation, with a comma between multiple states, and in alphabetical order.
- Are 5-15 hydrologic units nested within each level?
- Are hydrologic units consistently delineated across the state?
- Check the acreage of 10-digit watersheds confirming they are within the recommended range (40,000-250,000 acres). Check the acreage of 12-digit subwatersheds to see if they are within recommended range (10,000-40,000 acres with none below 3,000). There are situations where small sections of a hydrologic unit located within one state are less than 3,000 acres in that state, however the overall acres of the complete hydrologic unit should not be less than 3,000 acres.
- Does the coding of hydrologic units within a given level meet the guidelines for starting upstream and progressing downstream?
- Check and note in the attribute table any modifications such as non-contributing and diversions within a hydrologic unit boundary.
- Before submitting for national review and verification, verify the coverage is projected to Geographic or UTM, NAD83, GRS1980, meters, correct zone if UTM projection, and double precision. If not, re-project according to guidelines.
- Are the hydrologic units correctly delineated on the 1:24,000 scale topographic maps with respect to hydrography and elevation contours?

8.3 Provisional State Verification (Phase I)

Agencies involved in the development of the Watershed Boundary Dataset should establish organizational responsibility for reviewing and verifying the data before submitting the data to be reviewed and verified by the USDA-NRCS National Cartography & Geospatial Center (NCGC).

After the 6th level hydrologic units are completed, the originating office will submit the data to NCGC for provisional review and verification. Any supporting material (such as text documents describing the procedure used to delineate and digitize the watersheds and subwatersheds, a summary of findings for the watersheds and subwatersheds, and explanatory hard copy maps) would be beneficial for use in the provisional review.

Verification of HU data will be done by a phased method. Phase I will be a provisional verification by NCGC and an interagency review team. If the dataset meets the FGDC Proposal, Version 1.0 HU guidelines, NCGC will send a letter to the originating office stating that the HU data meets the national HU guidelines. If the HU data fails to meet the HU guidelines, the letter will state the problems with the dataset. Since the Version 1.0 standards for delineating HU's in coastal areas are incomplete, HU datasets meeting non-coastal area standards will be given provisional verification until the standards and methodology for delineating coastal areas is finalized by the FGDC Spatial Water Data Subcommittee.

Archive all verified geospatial files at your agency's geospatial archival center or clearinghouse.

8.4 Final National Verification (Phase II)

The second phase is a national verification completed by the member agencies of the FGDC Subcommittee on Spatial Water Data. The data must meet all the criteria as stated in the final approved FGDC "Federal Standards for Delineation of Hydrologic Unit Boundaries".

NCGC will make the data available via ftp to the member agencies of the Subcommittee on Spatial Water Data for review and verification (*Exhibit 9*). The chairman of the Spatial Water Data Subcommittee will coordinate the review with member agencies and report their findings to NCGC. The national verification will check for:

- adherence to the final FGDC interagency guidelines,
- mapping and delineation accuracy and consistency,
- coordination and matching of boundaries and codes across state boundaries,
- sizing, nesting, and coding of HU's, verification of the format and required fields listed in the attribute table,
- proper completion of metadata to FGDC standards.

NCGC will refer the review comments from the interagency team to the office that originated the HU dataset. After the dataset problems are resolved, NCGC will notify the Chair of the Subcommittee on Spatial Water Data that the state HU dataset meets the requirements of the final FGDC approved "Federal Standards for Delineation of Hydrologic Unit Boundaries". The

Chairman of the Subcommittee on Spatial Water Data will send a letter to the state specifying the HU dataset is approved and meets the HU guidelines.

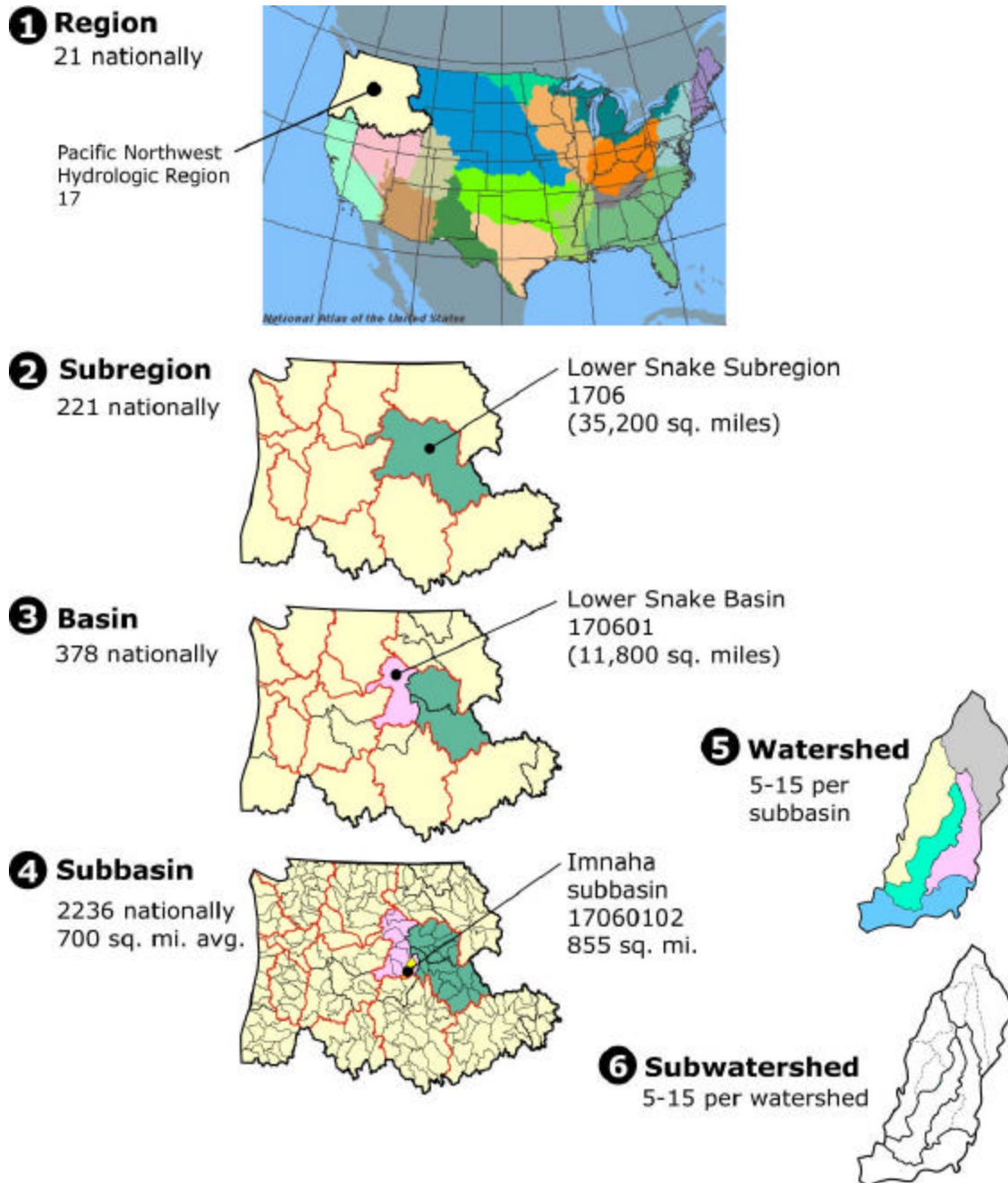
9. METADATA

According to an Executive Order signed by the President on April 11, 1994, all federal agencies developing geospatial data are required to document newly created data by completing metadata. The FGDC content standards for metadata are required. A sample of a completed FGDC compliant metadata template for hydrologic units is available from http://www.ftw.nrcs.usda.gov/huc_data.html.

10. APPENDICES

Appendix A: Illustrations.

Exhibit 1. Hydrologic Unit Hierarchy.



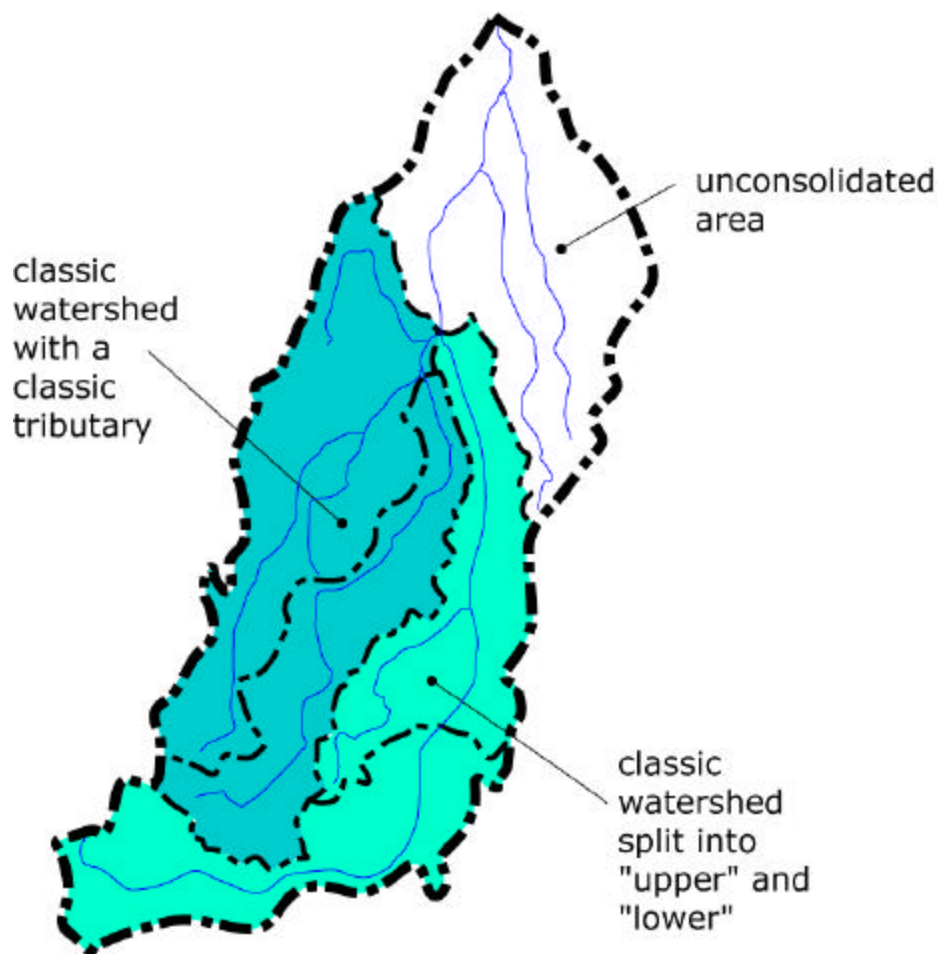


Exhibit 2. Sample of classic watershed.

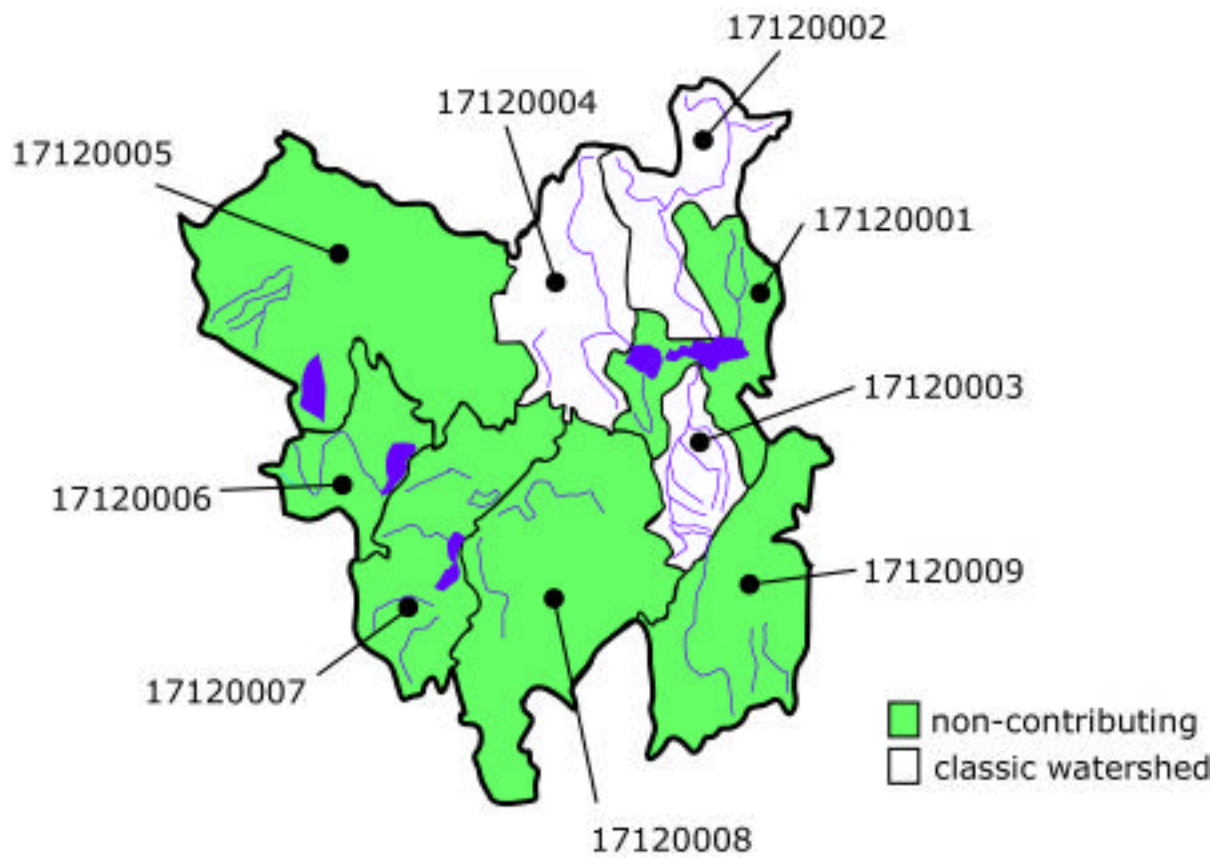


Exhibit 3. Sample of a non-contributing watershed within a sub-basin.

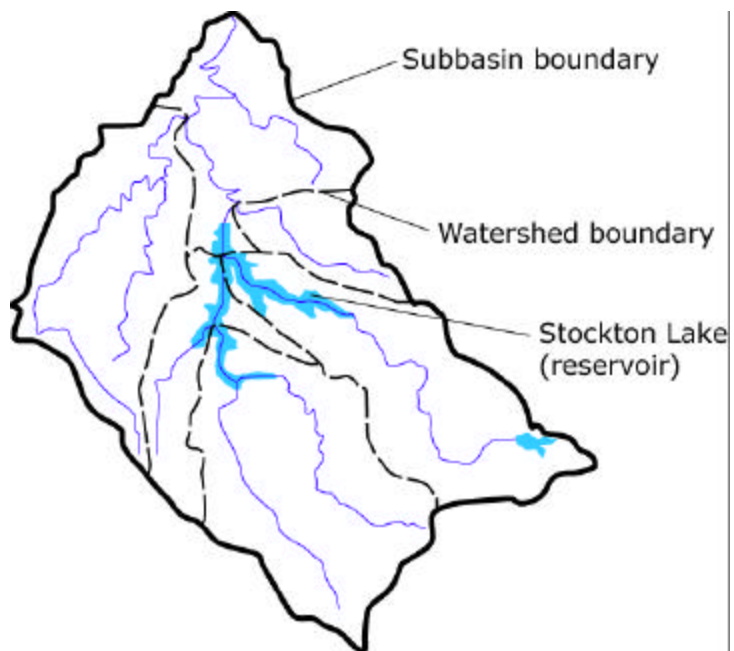


Exhibit 4. Sample of watershed delineation's within a sub-basin with a major reservoir.

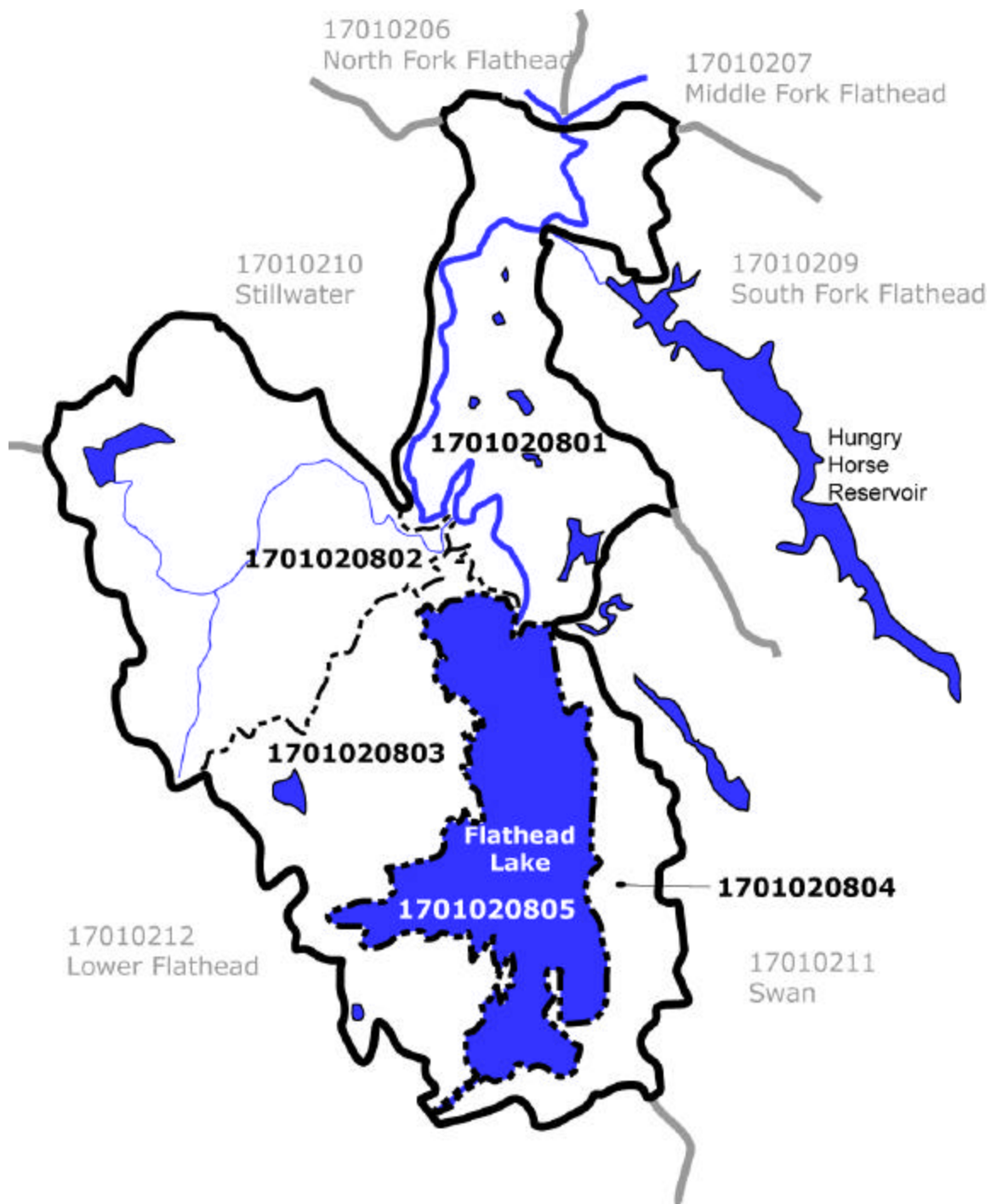


Exhibit 5. Sample delineation of a major lake as a separate 5th level hydrologic unit.

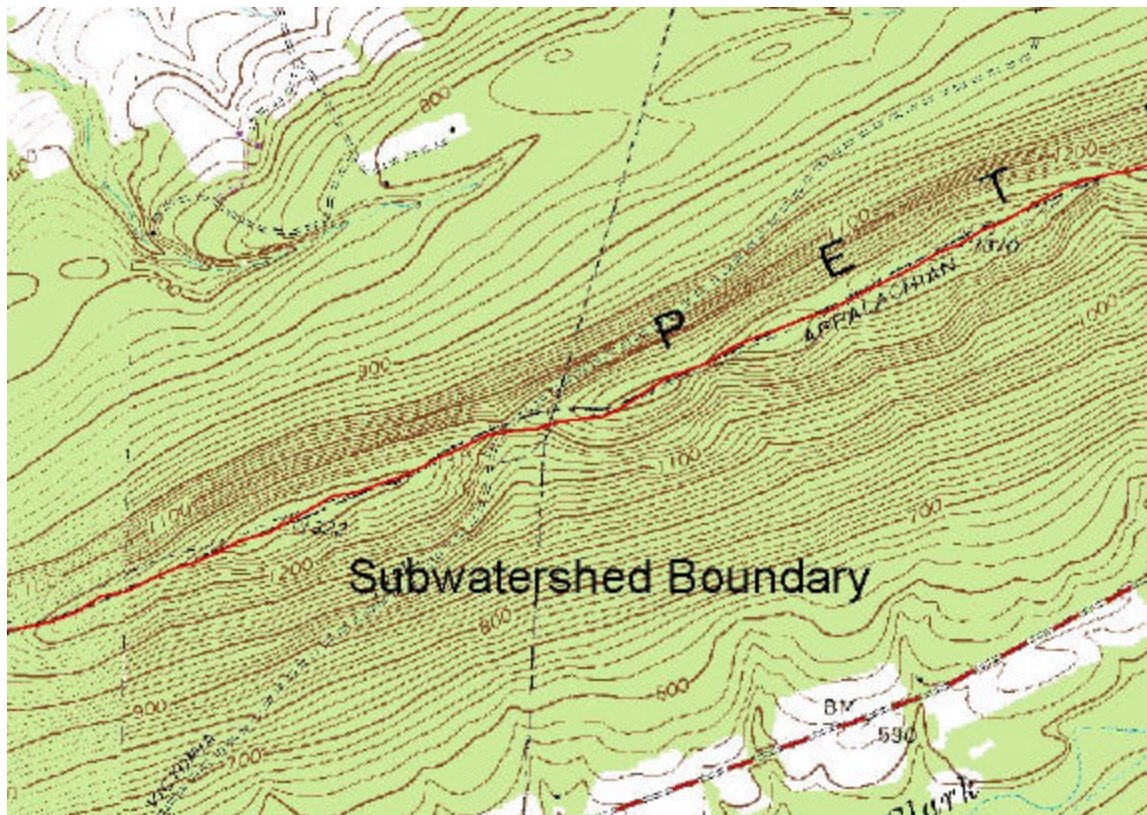


Exhibit 6. Subwatershed boundary shown in red is delineated correctly along ridgeline. It meets NMAS for 1:24,000 scale maps.

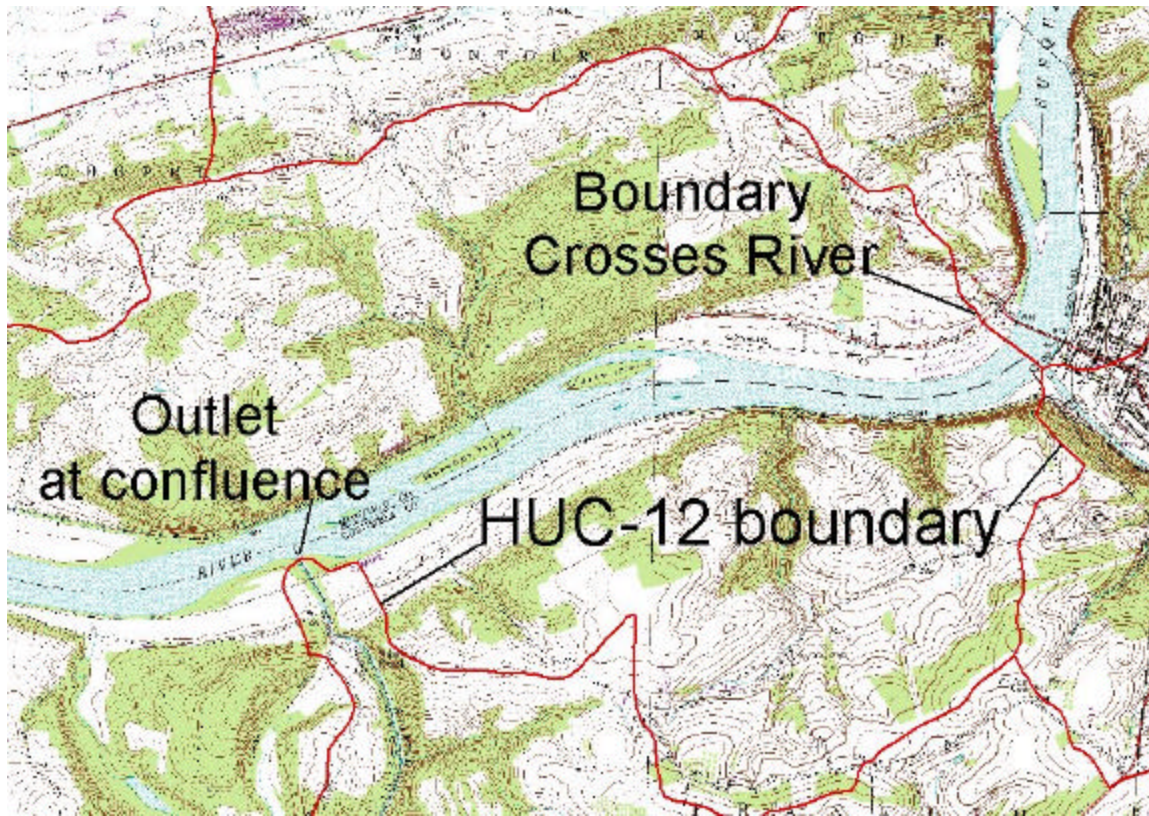


Exhibit 7. Subwatershed boundaries shown in red. Outlets located correctly at tributary side on the bank of the receiving stream at the confluence, boundary crosses perpendicular to river just upstream of confluence.

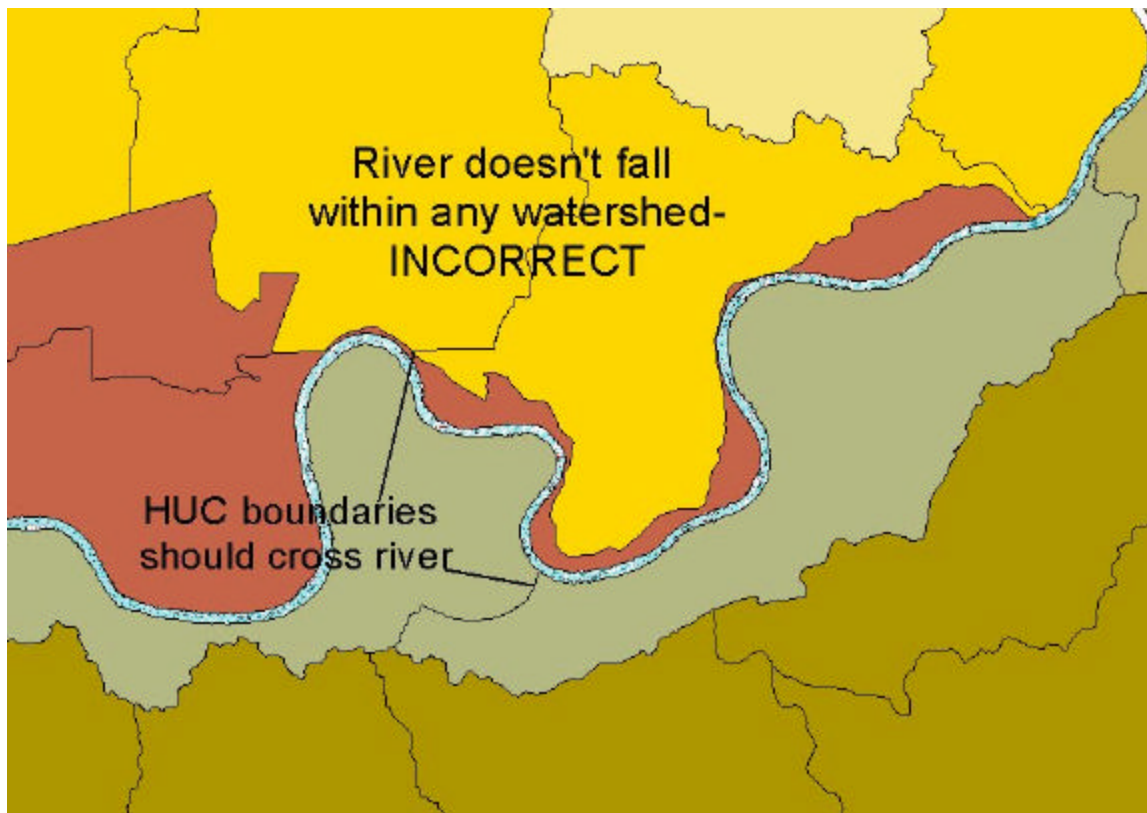


Exhibit 8. Subwatersheds (colored areas) delineated incorrectly along the river. The boundaries should cross the river or have outlets at tributaries.

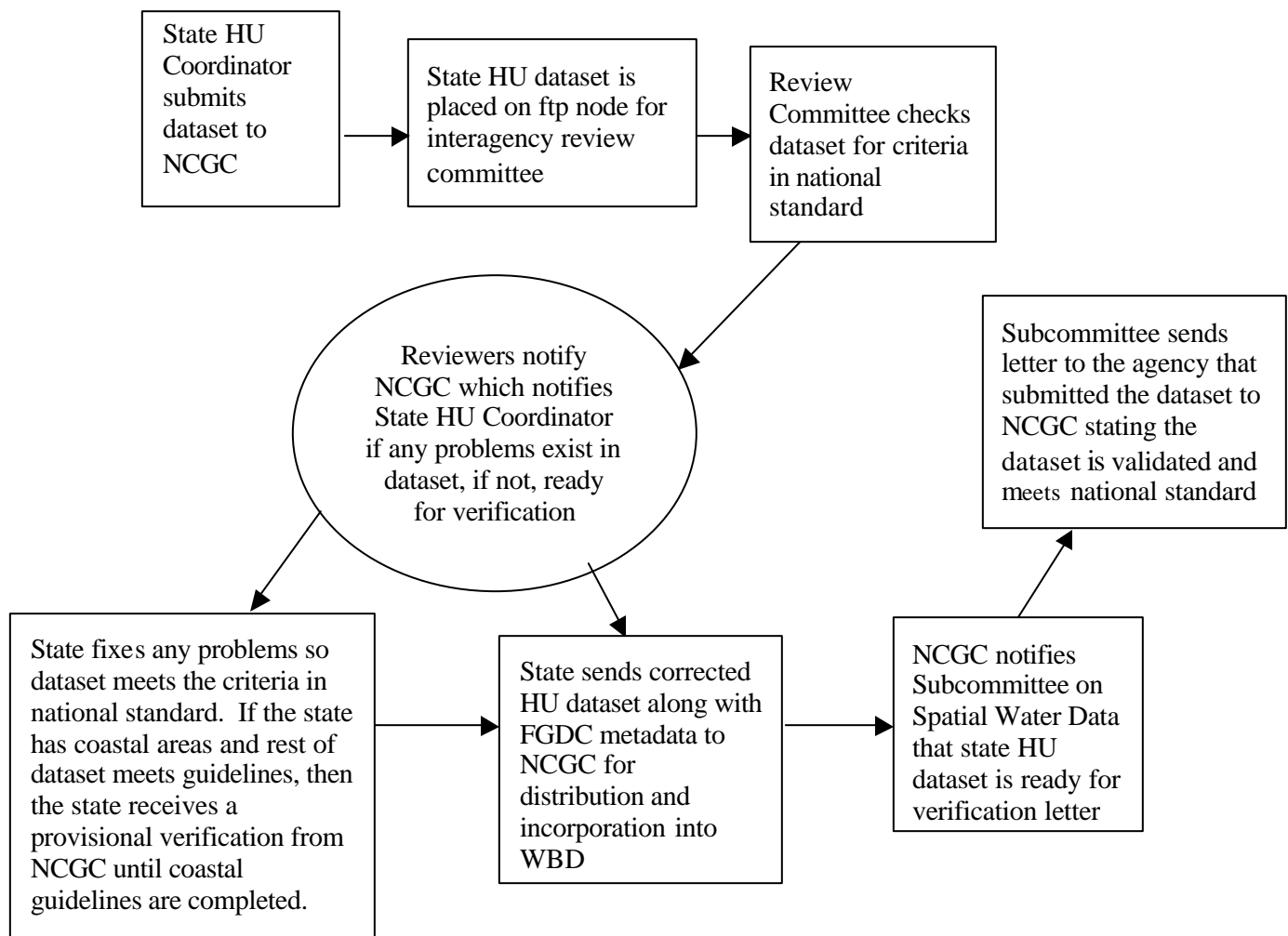


Exhibit 9. National Verification Procedure Flowchart.

Appendix B: Acronyms

ACWI	Advisory Committee on Water Information
BLM	Bureau of Land Management
DEM	Digital Elevation Model
DRG	Digital Raster Graphic
EDNA	Elevation Derivatives for National Applications
EPA	Environmental Protection Agency
FGDC	Federal Geographic Data Committee
FTP	File Transfer Protocol
GIS	Geographic Information System
HUC	Hydrologic Unit Code
NCGC	National Cartography & Geospatial Center
NED	National Elevation Dataset
NHD	National Hydrography Dataset
NMAS	National Map Accuracy Standards
NOAA	National Oceanic & Atmospheric Association
NRCS	Natural Resources Conservation Service
USDA	U.S. Department of Agriculture
USFS	U.S. Forest Service
USGS	U.S. Geological Survey
UTM	Universal Transverse Mercator
WBD	Watershed Boundary Dataset

Appendix C: Tables

Figure 1. Sample Edit and Quality Control Checklist.

SUB-BASIN NUMBER: 17010208 SUB-BASIN NAME: FLATHEAD LAKE		
	Name	Date
Base Map Plot	Lou Bayou	11-01-98
Draft Linework	Sandy Lake	11-15-98
Digitizing	Sandy Lake	12-31-98
Field Review		
Edits	Ray Bay	7-9-99
State Office Check		
Final Verification		

Figure 2. Sample Supplemental Process Notes.

Boundary Notes:

- Field Review Note: Surface waters in subwatershed 170102080140 appear to be completely diverted into the Columbia Falls city water supply. Confirmed this boundary by showing the return flow outlet location on Flathead River to include confluence.

- **Field Review Note:** Based on 1:24,000 topographic quad data, none of the 12-digit units were classified as subwatershed type "non-contributing". Field review included a careful check of units 170102080160 and 80 for possible non-contributing inclusions. Outlined all non-contributing areas greater than 1,000 acres in size.

- Watershed boundaries and coding significantly revised in Flathead Lake area from that shown in draft 10-digit watershed coverage. Flathead Lake covers an area of 125,415 acres, therefore stands alone as a 10-digit watershed.

- Pour point for Flathead Lake sub-basin is based on RF3 data and occurs at Kerr Dam, slightly downstream of the natural lake outlet.

Data Exceptions: Possible diverted flow in 170102080140. No significant non-contributing areas.

Watershed and Subwatershed Codes: See attached attribute table.

Attribute List: See attached attribute table.

1:24,000 DRG or Reference Topographic Quad List: See attached quad list.

Archived Items (State Office): Paper contour plots and index base map. Shapefile - mtsogis:/data4/av.chad/utm11/170102/08/dr208

Field Review Comments:

Edit Comments:

State Office Review Comments:

Final Verification Comments: